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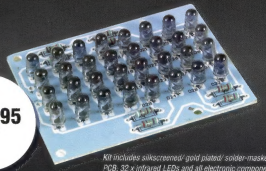

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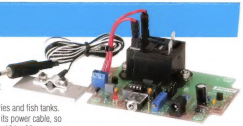

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Contents

SILICON CHIP

Vol.28, No.9; September 2015 www.siliconchip.com.au

Features

14 Autonomous Underwater Vehicles
Vast numbers of Autonomous Underwater Vehicles (AUVs) are in operation under the oceans around the world. We take a look at the vehicles currently in use and describe their missions – by Dr David Maddison

24 4K Monitor Shoot-Out
Fancy a big, ultra-high definition (4K) monitor for your PC? We put Bauhn's 42-inch 4K TV set up against a Philips BDM4065UC 40-inch 4K monitor – by Leo Simpson & Nicholas Vinen

40 Electronex: The Electronics Design & Assembly Expo
Electronex returns to Melbourne from 9-10th September

Projects To Build

30 Senator 10-Inch Bass Reflex Loudspeakers
Did you lust after the Majestic loudspeakers described in June 2014? Now we present a much less bulky loudspeaker system, still with high efficiency and high power handling but cheaper, easier to build and even (gulp) better looking. And they sound sensational – by Leo Simpson & Allan Linton-Smith

64 USB Charger Regulator With Low-Battery Cut-Out
This new version of the tiny USB supply described in the July 2015 issue now has extra circuitry to prevent any device, such as a dash-camera, from discharging the car's battery below 12.15V – by Nicholas Vinen

78 Build A 9-Channel Infrared Remote Control
Using a tiny, prebuilt remote, this IR remote control receiver has nine outputs that can be individually configured for momentary or toggle operation. The remote can even be used to control up to three separate receivers (each with seven channels) – by John Clarke

90 Ultra-LD Mk.4 200W RMS Power Amplifier, Pt.2
Second article has the full construction details for our new ultra-low-distortion amplifier module – by Nicholas Vinen

Special Columns

61 Circuit Notebook
(1) Benchtop Ignitor For Oxy-Acetylene Welding; (2) Efficient Linear Multi-Voltage Regulator

68 Serviceman's Log
One tricky job & one disgusting job – by Dave Thompson

102 Vintage Radio
The unique GE 675 5-transistor radio – by Ian Batty

Departments

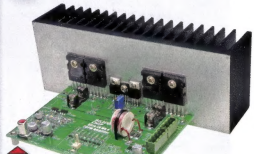
4 Publisher's Letter
6 Mailbag
52 Product Showcase
101 SC Online Shop
106 Ask Silicon Chip
111 Market Centre
112 Advertising Index
112 Notes & Errata

4K Monitor Shootout: Which Was Best? – Page 24.

Senator 10-Inch Bass Reflex Loudspeakers – Page 30.

USB Charger/Regulator With Low-Battery Cut-Out – Page 64.

Build A 9-Channel Infrared Remote Control – Page 78.



Ultra-LD Mk.4 200W RMS Power Amplifier, Pt.2 – Page 90.

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Publisher's Letter

SMDs present challenges and opportunities

For some years now we have been confronted with the reality that surface mount devices (SMDs) are rapidly supplanting through-hole components, ie, components with leads. In many cases, new electronic components are now not released in through-hole versions, so if we want to use these new devices in our projects, it is SMD or nothing.

We know that some readers do not like SMDs, because they are much smaller, can be more difficult to handle and to solder – or at least that is how some people react. In fact, in some ways, SMDs are easier to handle than through-hole components. Yes, they are smaller but you don't have to bother with poking tiny leads through holes in the PCB and you don't have to worry about them falling out of the PCB when you flip it over to solder the components. Nor do you have to clip off the pigtails and so on.

You can install all the SMDs required on one side of the PCB in one go. It can actually be quicker than assembling the same circuit with conventional through-hole components and arguably, the finished article looks better. Yes, you do need very good vision or if you are not so fortunate (with the keen eyesight of the young), you need magnifying aids. But realistically, such aids have always been required if you are to properly inspect your soldering in any case.

So that covers the challenges. Then there are the opportunities to consider. One reader in this month's Mailbag pages has asked about the possibility of designing PCBs which can be used in a variety of different projects, with the same powerful surface-mount microprocessor surrounded by a bunch of through-hole components, some or all of which may be installed, depending on the features required.

Well, we think that is such a good idea that we have already done it, in projects featured in the November 2013, February 2014 and October 2014 issues. However, we did not make a big thing about it at the time because it seemed like a logical process and not an earth-shaking development. The reader who made the suggestion could be forgiven for not realising that the idea had already been used. It's a bit like having passed through a small country town at speed – blink and you might have missed it.

But SMDs offer other opportunities and a great example is evidenced by the PCB of the new Ultra-LD Mk4 high-performance amplifier module which is featured in this issue. This article includes photos of the final PCB design and if this is compared with the prototype PCB in the July & August issues, you will see that there are quite a lot more SMDs on the final version. That is because we have incorporated more features, something that we just could not have done if the PCB used only through-hole components; a much larger PCB would have been required.

Perhaps the key added feature is the clipping indicator, which means that users will be able to avoid inadvertently driving the amplifier into clipping and audible distortion.

So not only were we able to produce a PCB with much improved topology compared to the previous Mk3 version, as well as give it a smaller footprint, we were able to add desirable features which were simply not envisaged when the original design was produced quite a few months ago.

I still find SMDs mind boggling compared to the equivalent through-hole components. But we have been through the same adjustment process in the past as new technology has been introduced. No doubt it will all happen again in the future.

Leo Simpson

Smart Lights Are Better Lights

Modern LED lighting applications require more than just the capability to be turned on and off. Designers need a solution that offers digital control to smooth dimming, as well as color temperature tuning, usage-based lifetime prediction and networked communication for monitoring and control. Also don't forget the challenge of complying with changing efficiency standards.

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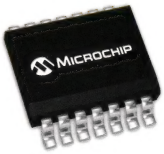

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Grid-tied inverters don't export power

I am writing to respond to a couple of items in the Publisher's Letter in the July 2015 issue.

It was good to see some factual data about the workings of grid-connect inverters and the importance of line isolation/protection during blackout. He makes a reference towards the end of his article that there are now hybrid grid-tied inverters available but this style of inverter has been around for many years. It would have been late 1997 when I first helped to install a solar-grid-battery inverter (now called a hybrid inverter) into a house in Adelaide.

This was a unit made by Xantrex and there was a 24V battery bank. If a blackout occurred then a switch had to be manually turned for the household circuits to be supplied with energy from the batteries. The accompanying photo shows the installation. A web search for "Xantrex Trace" will take you to the website and provide you with much technical information on the inverter.

The second item relates to a very basic error that Leo Simpson made in referring to the "power" one exports back to the grid. I can assure you that

nobody has been paid a cent by electrical retailers for exporting kilowatts (power) back to the grid. As Leo would know very well, power is an instantaneous value and it is kWh (electrical energy) that is fed back to the grid, because 'time' comes into the equation. Non-technical people can be forgiven for making such a basic error but I am surprised that Leo Simpson let that one get through.

A 5kW solar power system has the capacity to provide about 21A (at 240VAC) into the grid and the electricity retailer does not pay for the power rating of the PV system but for the amount of electrical energy (in amps) that has actually flowed into the grid over time. Power is not supplied or consumed; energy is.

Aussie Kanck,
Athelstone. SA.

Comment: it is true that payments are made for kilowatt-hours but power is energy/time, ie, the rate of energy delivery, so we cannot see a problem with the concept of exporting power. Most people tend to think in terms of "power consumption" even though everyone knows that it is energy which is being consumed or used.

Windows can squander your data allocation without asking

Recently I was touring in Europe and for the duration I purchased a local SIM with 1GB of data to go in my mobile phone. I normally use the mobile in tethering mode so my laptop would see a WiFi connection to the internet and I estimated that 1GB would be more than enough for a month of emails and general web browsing.

But the whole data allocation vanished in a week and it turned out that Microsoft had consumed it all without asking. Before I left for Europe a Windows update had installed the "Get Windows 10" icon in the task bar of my laptop. At the time I ignored it, figuring that I would "reserve" my update when I returned from abroad and then incur the download over my home broadband. But it seems that Microsoft went ahead and started the download anyway and consumed my expensive mobile data allocation. Very annoying and thanks to Microsoft I had to pay for an additional data allocation.

This illustrates a worrying trend. This is that the update service that many vendors use gives them unlimited access to your computer and they can use that to further their own aims, in possible conflict with your interests. Microsoft installed a piece of software on my machine (without asking) and then went ahead and downloaded a huge amount of data also without asking.

One of the features of Windows 10 is that you cannot opt out of their automatic update service. So now they will have hundreds of millions of computers under their complete control.

Sure, Microsoft would not intentionally hurt their customers but who can predict what they will do if a future CEO is desperate for increased profits or market share.

Geoff Graham,
Kensington, WA.

Wireless door chime repeater component change

I would like to thank Mr Forsey for his idea in the Circuit Notebook of June 2015, for a wireless door chime

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Mailbag: continued

Headphone amplifier for hearing-impaired

I would be very interested in a programmable headphone amplifier as I have a moderate hearing impediment. Because my higher frequency hearing drops off, I built your Super Ear project from the May 1998 issue of *Electronics Australia*. It works well; even better than my $6000 hearing aid but I have no sense of direction.

These days with mobile phones, iPods pods etc, it would not be out of place to wear headphones, so modified headphones with forward-facing microphones connected to a small enclosure that fits in your shirt pocket could work. I would suggest that it has adjustable dynamic range compression, independent preset volume on each channel (each ear) and a programmable graphic equaliser. It should also an inbuilt USB socket for customising the presets and recharging the battery.

I know this is a lot to ask but I feel it would be "doable". It would not need to be a cheap project as it could help a lot of people.

Jim Brickwood,
Oatley, NSW.

repeater which I now have successfully working. However, whilst the unit as designed worked when connected in isolation to the transformer lines (in my case, 14.5VAC open-circuit), when the chime was reconnected in parallel it failed.

A little thought suggested that the additional loading of the chime was dropping the line voltage to the point where the high value of the LED current limiting resistor (10kΩ) was preventing the LED from triggering the photo transistor. Reducing the value of R1 to 2.2kΩ has resulted in a reliably functioning unit.

Dennis Fieldhouse,
Bentleigh, Vic.

Hearing-impaired headphone project suggestions

In the Ask Silicon Chip for June 2015, a reader requested a project for an amplifier which has an adjustable equaliser which would mirror the hearing loss curve of individual hearing-impaired people. I believe this would be a popular project with the elderly as they often have trouble understanding what's being said on TV.

I considered opening a noise-cancelling headphone and experimenting by placing an equaliser to roughly mirror my hearing loss between the earpieces and amplifier, with two very directional microphones to pick up nearby conversations. If this was possible it would be far cheaper than purchasing hearing aids. I have not done this and instead purchased a pair from Blamey & Saunders.

Wearing headphones in these times isn't seen as a disability. I would immediately build a project like this if it was available and probably show it to a number of friends in my age group.

Alf Leaver,
via email.

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Small solar panel installations are still attractive

For those considering installing solar panels, David Voight's discouraging comments in the Mailbag pages of the August 2015 issue should not be taken as the norm. His 4.8kW panels produced the equivalent of only three hours of rated power per day (14.2kWh) in the period from 1st January to 1st April 2015.

By comparison, mine in Perth facing north on a 20° roof slope produced the equivalent of 5.5 hours per day in the same period and they average 4.5 hours per day annually.

Costing about $2000, a north-facing six-panel 1.5kW PV installation in Perth should generate on average 6.9kWh per day. Assuming that 2/3 is used and the other 1/3 fed back into the grid, the annual cost saving, using David's electricity rates would be **(4.6kWh x 36.12c x 365 days) + (2.3kWh x 6.2c x 365) = $660,** giving an attractive 33% tax-free return on investment.

The small contribution towards reducing carbon emissions is a further plus. Because the solar rebate is so small these days, the trick is to install little more than you can use.

John Muller,
Carine, WA.

Comment: most installations would not be able to use two-thirds of the energy generated by the solar panels and export one third to the grid. The actual payback on any solar panel installation will depend on the time-of-day tariffs charged by the smart meter. If there is little home consumption during the day when solar power is being generated, and high domestic consumption at peak and shoulder times, the payback on investment may be very small.

Popular valve book available again

SILICON CHIP readers and DIY valve audio enthusiasts may like to know that "A Modification Manual for Vacuum Tube Electronics" is again available. TU-BE or not TU-BE was written by Ike Eisenson, a researcher for sound perfection. There are 210 double pages of tried and tested circuits, hints, tricks and step-by-step circuit modifications for famous brands such Eico, Citation, Marantz, Scott, Dynaco and Fisher.

It is available from Dave Riddle of DRCO. Phone toll free from Australia 0111 800 544 3746. It costs $US25 plus $US8 for postage to Australia.

Lindsay George,
Cowes, Vic.

Errors in published circuit

I note that a number of changes were made to my PICAXE-Based Mains Timer in the the Circuit Notebook pages of the August 2015 issue. The problem lies with the status indicator LEDs. I had included series diodes (D1 & D2) together with 560Ω current limiting resistors. These diodes have been omitted in the published circuit and the current limiting resistors have been increased to 1.2kΩ.

Adding these diodes ensures the total forward voltage drop across the semiconductors is greater than the 5V supply voltage (with 560Ω current limiting resistors) and thus prevents both LEDs turning on briefly as the microcontroller initially powers up. The higher value current-limiting resistors may also reduce the LED brightness with common "bulk pack" LEDs.

Also the re-numbering of the diodes in the bridge rectifier, together with the labelling of the device types underneath the circuit, implies that D1 & D2 could be 1N4148 types when they should be 1N4004 types.

Ian Robertson,
Engadine, NSW.

Comment: readers should note that diodes D1-D5 are all 1N4004 types. The on-line version has been corrected.

Optimism about off-grid solar installations

I noticed that were some negative comments in the July 2015 issue that "off grid solar" was never going to work. That might have been true 15 years ago. A few years before that time, getting electrical power from the Sun was looked on as amazing but solar panel prices were in the $10,000 range. People were waiting for them to become available at a more affordable price.

Around 2000 they were on the market for $10 a watt and many campers decided it was good idea to buy one. Usually about 75W to 80W for just short of $1000 was considered a good buy, coupled with a cheap car battery. Off they went and then found problems even on the first night. Down the track, the car battery would fail altogether, as they are only designed deliver a high current for a few

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Mailbag: continued

Exterior plastic enclosures need to be UV-stabilised

In this August 2015 Publisher's Letter, attention was brought to some poor safety and construction standards of particular LED floodlights. I am not surprised. However something visible but hidden was missed: the quality of the plastic. I bet that the plastic will be discoloured and brittle within a short time and perhaps as short as six months if it is exposed directly to the Sun.

Much of today's plastic goods do not contain anti-oxidants and UV stabilisers. Under the action of ozone and UV, plastics change their chemistry. In fact, a friend who had a business as an electronics recycler used this fact to ease processing. Old electronics such as printers, fax machiness and scanners were exposed to the Sun for weeks to months after which they literally fell apart in some cases. Unfortunately, I have also seen 240VAC-rated enclosures and ducting crumble in sheltered locations. Australian standards need to be improved.

Years ago, a number of magazines published electronic cook books and circuit examples etc. Now we have the internet and there is a huge amount of information and circuits available if they can be found (and trusted!). Unfortunately, a search will usually result in links to sellers and little else but on occasion a good link will be returned. Such a link is the following:
www.phy.davidson.edu/instrumentation/NEETS.htm

The web page contains the 24 modules of the US Navy's Electricity and Electronics Training Series. The modules are from 1998 and are stated as approved for public release and unlimited distribution. The information is basic and a bit dated in parts but for anyone beginning in electronics, these modules would be a good addition to a reference library.

Earlier this year, SILICON CHIP published one of my letters in which I complained about the need to load MPLAB X and talk to Microchip just so that I could use a PICkit 3 programmer. A little while ago, I decided to load MPLAB X even if it did trash my existing installation. To my surprise, the installation procedure has the option to load either the IDE or the IPE or both. The IPE (Integrated Programming Environment) is all that is required to use the PICkit 3 programmer.

George Ramsay,
Holland Park, Qld.

seconds. The plates are made of spongy material so it offers a large area to the electrolyte to achieve this high current and it will fall to pieces very quickly if used to discharge deeply and charge at a campsite.

A deep-cycle battery that is large enough for everything with at least 50% to spare must be used and the solar panels must also be large enough to have the battery fully charged by early afternoon with whatever is connected to it throughout the day after a night's drain.

With what people tried back then and the high drain of the fridges they used then, it is no wonder that some are against solar panel/battery set-ups. Get everything right and the batteries should last 10-20 years while the panels should last a lifetime. As far as expense goes, you can now buy solar panels for as little as $1 a watt so that's only $2000 for 2000W. Divide that by your life-time and that's very cheap.

Deep cycle batteries are only $160 each for 12V 100Ah at the cheap auto shops around Christmas time. That's only $800 for 500Ah; less than most people pay for their electricity bill for the year and if they last 10 years, that works out to $80 a year or only $20 a quarter. Should they last 20 years, that's only $10 a quarter.

As far as the regulator goes, you can build one yourself. I have built one for less than $20 that will provide a 100A output. If you have a good regulator and the above you should have trouble-free running of your home for 10 years, if not more.

As far as cloud cover knocking off the charge rate, that's not true either. On a totally overcast day you get a

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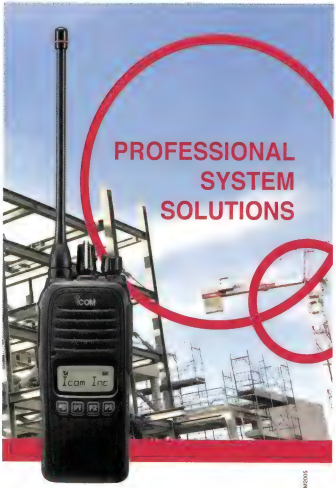

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Mailbag: continued

Nostalgic memories of the long wait

I did enjoy the Serviceman's Log in the May 2015 issue, when Dave Thompson related his apprenticeship tales of gags being played on him as a newcomer. I remember well when I was an apprentice, coincidentally also in the airline industry, when the "long weight" gag was pulled on me by my boss. I had already heard of the gag from older apprentices, so when it was played on me, I was prepared.

My boss asked me to go to the store room and ask for the "long weight", as we needed it to counterbalance a forklift truck which was to pick up an armature which weighed about 500kg. I was a bit unsure if this was a genuine request but I did not want to question my boss's order. So I walked off to stores and requested the "long weight", from the storeman. I saw the fleeting smirk on his face before he turned to the other store-man and asked him where the "long weight" was kept.

The storeman told me to wait and he walked off to find it. After he had been gone a minute or so, I told the other storeman that I needed to go to the toilet. I walked off but I did not go back to the stores but to the Apprentice Workshop. I had a nice chat with the new apprentices for about 10 minutes and then headed off to the Battery Room, where a friend worked, for another chat.

I then quickly stopped in the Instrument Section for another chat and then headed down to the hanger, where other friends worked. After another 10-minute chat, I had a quick browse in the company's library and then headed back to the company's stores.

When the storeman saw me, he exploded with anger and asked me where in the hell had I been? I meekly said that I had been to the toilet. He told me to go straight back to my section and to report to my boss immediately. My boss did not mention the "long wait"; he did not even ask me where I had been. He just banned me from going to the stores for a month!

Anthony Farrell,
Kingscliff, NSW.

constant charge from sunrise to sunset. Depending on the cloud type, it will range from 20% to above 90%. On totally clear days the panels become a bit directional but not just for an hour at noon. Full output actually occurs 30° either side of direct sun, making it 60° in all which at 15° an hour gives you four hours at full power on bright clear days, only dropping off by small amount once past these points. At 50° from the noon sun, you still get 70% or more.

I have been using my solar system for over two years and I have now upgraded to 2kW of solar panels. With the 100A regulator, there are few days when the 500Ah batteries are not fully charged by noon and in all conditions they are fully charged by 3pm local time.

As far as the perfect battery never coming, I believe it is already here as we have been using phones with lithium batteries for 10 years. Some people still have these phones and the battery is still as good as the day they got it. Lithium batteries don't care how low they go or when you charge them or how much you charge them. They are still too expensive at the moment (over $1000 for a 100Ah battery) but just as solar panel prices have became affordable so will these, as history repeats itself.

David Francis,
Kilburn, SA.

Comment: anyone expecting long life from second-hand deep cycle batteries is being very optimistic. Lithium batteries can certainly be discharged to a much greater degree than deep-cycle lead-acid batteries but they require very careful charge control.

Old power supply wanted

I would like to reach out to the SILICON CHIP readers to see if anyone has a Dick Smith Electronics power supply, model Q-1765. These were sold around 2006/2007. I realise similar supplies can be bought new but I'm hoping to find an original Q-1765. If anyone has one they'd part with they can contact me at 898kiwifm@gmail.com

Thank you for your assistance. I still look forward to reading the new edition of SILICON CHIP each month.

Stuart Williamson,
Auckland, NZ.

How about multi-project SMD microcontroller PCBs?

Has SILICON CHIP considered designing multi-project PCB designs with both SMD and through-hole components – on the same PCB? That way, you could have one multi-functional PCB design for maybe five to six projects with one-off development cost and less waste of unsold stock.

Like many hobbyists, I find SMD components hard to use but many new SMD micros offer more power and features than older through-hole micros. So my idea is for a PCB with a core of SMD components but with an unpopulated area for through-hole devices. Each project would use the same SMD core but with different through-hole components, depending on the project.

This approach is similar to the Arduino concept with a common microcontroller with complementary components that facilitate programming and provide differing features. If Arduino can do it, what can SILICON CHIP produce?

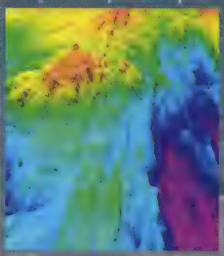
John Crowhurst,
Mitchell Park, SA.

Comment: three recent projects in SILICON CHIP have used the same PCB, SMD microcontroller and codec chips and a variety of different through-hole components. They are the Dual-Channel Audio Delay for PA systems in the November 2013 issue, the Stereo Echo & Reverberation Unit in the February 2014 issue and the Digital Effects Processor for Guitars/Musical Instruments in the October 2014 issue.

If you count all the possible variants of the Digital Effects Processor, such as Echo, Reverb, Tremelo, Vibrator, Fuzz, the total number of projects that can be produced with this one PCB is eleven or more. SC

Autonomous Underwater Vehic

Secret missions under the world's



By Dr David Maddison

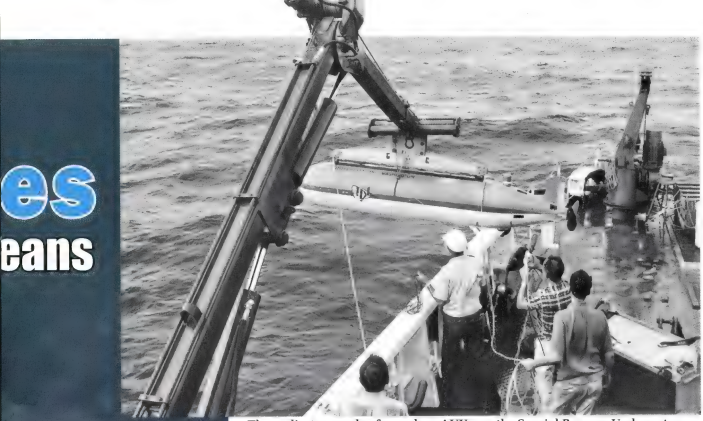
Autonomous Underwater Vehicles (AUVs) need not merely float at the whim of tides and currents. They can travel along predetermined routes for thousands of kilometres. They can search for crashed aircraft or sunken ships, do mineralogical surveys of the ocean floor, measure ocean temperature or salinity and perform many other types of mission.

VAST NUMBERS of AUVs are in operation around the world and they are used for anti-submarine warfare, beach and sand migration surveys, underwater cable deployment and route surveys, coastal mapping, environmental monitoring, explosive ordinance disposal, military force protection, underwater mapping and geophysical survey, harbour and port security, hull inspection, acoustic research, inspection, maintenance and repair of underwater structures, intelligence, surveillance and reconnaissance, marine science surveys, mine countermeasures and mineral exploration.

SILICON CHIP has previously covered the Argo buoys in the July 2014 article "Argo: Drones Of The Deep Oceans". Australia is one of the lead players in the Argo program, involving thousands of AUVs gathering information about temperature, salinity, currents, biological data and other parameters of the world's oceans. But the Argo AUVs merely float at the whim of the ocean currents.

Other AUVs can go where they are programmed to go. They come in a range of body shapes, such as:

- biomimetic (emulating a biological organism in form or propulsive method);
- blended wing body;
- submarine shape;



The earliest example of a modern AUV was the Special Purpose Underwater Research Vehicle (SPURV) developed at the University of Washington in 1957 and operated by the US Navy for research until 1979. It could dive to 3000m and had an endurance of 5.5 hours.

A large database of AUVs can be seen at http://auvac.org/

Ocean gliders

Most conventional AUVs cannot travel long distances because of battery limitations. Ocean gliders are AUVs which have hydroplanes (underwater wings) and are designed to travel long distances, unlike drifting devices such as Argo that can only go where currents take them.

Ocean gliders work by gliding down from the surface to some specified depth and then rising to the surface where they may transmit their data to a satellite or surface vessel. They then glide down through the depths again, collecting data as they go.

The wings enable them to convert some of their vertical motion to forward motion. Thus they follow a sawtooth or sinewave-like pattern to propel themselves forwards along their route of choice. Mission durations can be many months and can cover many thousands of kilometres.

An animation of a typical ocean glider can be viewed at: https://youtu.be/J3ViBke2ZQg

The first ocean glider was designed in 1960 (by Ewan Fallon) to carry a scuba diver, although the vehicle itself was not autonomous.

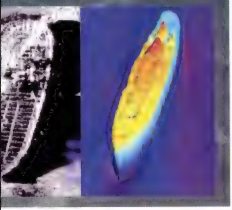
Typical ocean gliders are controlled by a buoyancy engine powered by a heat exchanger. It uses heat difference between the ocean surface at near air temperature and the lower temperatures in the depths (typically, 2-4°C).

Buoyancy engine

The thermal engine consists of a heat exchange tube, accumulator, valve manifold and two bladders, one external and one inside the pressure hull. The heat exchange tube comprises an outer aluminium pressure vessel that is filled with a wax which undergoes a phase change (melts or freezes) at 10°C.

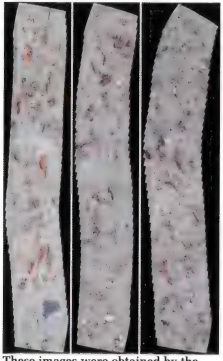
In the centre of the wax is a flexible hose filled with mineral oil. In operation, the glider dives from the surface by rotating the valve and allowing oil from the external bladder to enter the internal bladder, thereby decreasing the overall volume and causing the vehicle to descend.

Prior to leaving the ocean surface, the accumulator, backed by a tank with nitrogen at 3000 PSI, must be charged with oil while the wax in the thermal heat exchange tube is in a liquid state.



- oblate (roughly spherical in shape but flattened at the poles);
- open-space frame – little attempt at streamlining or covering components;
- rectangular;
- tear-drop shaped;
- torpedo;
- torpedo with wings;
- crawler (a wheeled or tracked AUV that drives along the sea bed) plus other designs that don't fit into these categories.

Called "Sirius", this AUV is operated by the Australian Autonomous Underwater Vehicle Facility and is a modified version of a vehicle called "SeaBED", developed by the Woods Hole Oceanographic Institution in the USA. It's shown here surveying the coral reefs around Scott Reef, WA.



These images were obtained by the Sirius AUV from Ningaloo Reef off WA and show sponge beds at a depth of 80m (the images were taken from a height of 2m above the seabed). Each of these three mosaic pictures is made up from 40 images, 10m long and around 1.5m wide.

As the glider dives, it passes through the 10°C thermocline into colder waters and the wax begins to freeze and contract, allowing oil to be drawn into the flexible centre hose in the heat exchanger from an internal bladder.

When the glider reaches 1200m, the valve turns again and the accumulator pushes oil to the external bladder, overcoming the hydrostatic pressure, increasing the vehicle's volume and causing the vehicle to rise. As it passes through the 10°C thermocline into the warmer surface waters, the wax melts, expanding and forcing the oil in the middle hose out at high pressure into the accumulator, thus re-charging the system for the next dive.

Because the energy for freezing and melting the wax comes from the ocean itself, no external power is required. This makes this type of AUV extremely energy efficient as no internal power is needed for propulsion – see http://auvac.org/configurations/view/51

One author, Christopher Von Alt, has argued that the first AUV was the Whitehead Torpedo designed in 1866 and in service from 1894-1922. It had a range of 700m, could travel at 3m/s and was driven by compressed air. It had a navigation system to keep it at a preset depth and later versions incorporated a gyroscope. Whether it was truly an AUV or not, it was of an overall design still used today for torpedoes and many AUVs.

The earliest widely accepted example of a modern AUV was the Special Purpose Underwater Research Vehicle (SPURV) developed at the University of Washington from 1957 and operated by the US Navy for research purposes until 1979. It could dive to 3000m and had an endurance of 5.5 hours. It was used to study underwater acoustics, submarine wakes and dye diffusion (which had relevance to the diffusion of submarine wakes), plus other work relevant to submarines. Its hydrodynamic design was calculated on an analog computer.

SPURV weighed 480kg and had a speed of 2.2m/s. While the vehicle could be acoustically controlled from the surface, it could run autonomously in modes such as maintaining a constant pressure (ie, depth) or constantly climb and dive between two different depths in a see-saw manner.

There were a number of other early AUVs but these were generally expensive, inefficient or large because the available technology was not really adequate. It was not until the advent of powerful microprocessors in the early 1980s that AUVs became viable. High energy density power sources such as lithium-ion batteries have also contributed to the design of practical AUVs. By 1987, there were six AUVs in operation and a further 15 prototypes under development or construction according to Busby Associates' "Undersea Vehicle Directory" of that year.

IMOS (Integrated Marine Observing System)

One of the support organisations for the Argo AUV is IMOS, Australia's Integrated Marine Observing System (IMOS) – see www.imos.org.au

IMOS is a collaborative research organisation supported by the Australian Government and led by the University of Tasmania. It is responsible for the integration and management of data from 10 major facilities operated by nine institutions.

Data is collected from the Argo floats, sensors on commercial ships and deep water moorings, ocean gliders, autonomous underwater vehicles, instrumentation stations moored at sea, ocean radar (to monitor surface currents over areas of 150 x 150km of coastal ocean), animal tags and monitors, satellite sensors and wireless sensor networks (eg, networks of sensors such as those installed in the Barrier Reef and which stream ocean data such as temperature and salinity). You can peruse a vast amount of IMOS data at http://imos.org.au/imosdatatools.html

If you go to the AUV Images Viewer

A recent trip made by ocean glider sh153 as part of the "Lizard" project off Cooktown, Qld. The 200km trip took 13 days and involved 156 dives. You can follow the journeys of such gliders at https://auv.aodn.org.au/auv/

An Australian ANFOG Seaglider on the deck of a support vessel.

at https://auv.aodn.org.au/auv/ you can zoom in an area of interest on a map of Australia or select an area from a tracks list and then view images taken on that mission.

The two facilities involved with IMOS that utilise AUVs (apart from Argo) are the Australian Autonomous Underwater Vehicle Facility (AAUVF) and the Australian National Facility for Ocean Gliders (ANFOG).

Sirius

The Australian Autonomous Underwater Vehicle Facility operates an AUV called "Sirius". This is a modified version of a vehicle called the SeaBED, developed by the Woods Hole Oceanographic Institution in the USA. It is an open space frame design, 2m long, 1.5m wide and 1.5m high. It weighs around 200kg, works to a depth of 700m and can travel at a speed of about two knots, its primary mission being sea-bed mapping and environmental monitoring.

Sirius has a 1.5kWh Li-ion battery pack and three 150W brushless DC thrusters. It includes a high-resolution stereo camera; a 330kHz multi-beam sonar; depth, conductivity and temperature sensors; and sensors to measure dissolved organic matter and the amount of chlorophyll present.

The navigational suite includes a 1200kHz Doppler velocity log with compass, roll and pitch sensors, an ultra short baseline acoustic positioning system and a forward-looking obstacle avoidance sonar, with GPS for use at the surface. All data is geo-referenced.

Typical mission profiles (programmed before launch) include following a particular line (transect) or covering an area with a grid pattern. Typical imaging takes place at a constant height of 2m above the sea floor.

ANFOG gliders

The Australian National Facility for Ocean Gliders (ANFOG) operates two types of gliders, the Seaglider and the Slocum. You can see a zoomable map showing where ANFOG's gliders are active at http://anfog.ecm.uwa.edu.au/index.php

Seaglider is intended for long duration missions of many months and thousands of kilometres. It was developed by the University of Washington and since May 2013 has been produced under license by Kongsberg Underwater Technology, Inc. (a US division of the Norwegian company).

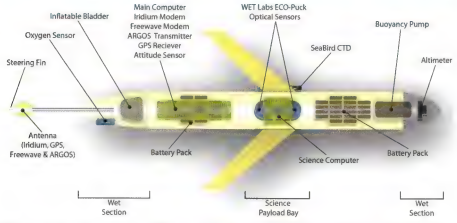
Like other ocean gliders, Seaglider "flies" through the water in a sawtooth-like pattern. It uses its wings for gliding, has adjustable buoyancy and its battery is used as an adjustable ballast to alter pitch and roll. It can operate to a depth of 1000m, is 1.8-2.0m long and weighs 52kg dry. In standard configuration, it has a range of 4600km, involving 650 dives to 1000m, and has a speed of 25cm/s or 0.5 knot.

Seaglider is suitable for civilian or military use and can carry a wide variety of sensors. According to Kongsberg, its uses include physical, chemical, biological and tactical oceanography, environmental monitoring, storm monitoring and intelligence, surveillance and reconnaissance. It can also be used as a data gateway, as a navigation aid, for active or passive acoustic monitoring of sealife, for current profiling, and for tracking and data capture from acoustic tags.

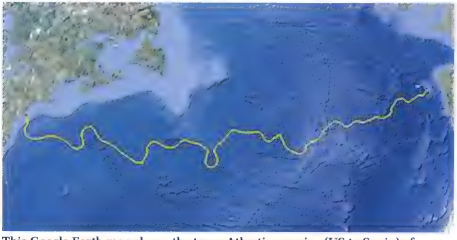
Typical sensors for biological use are current profilers, conductivity and temperature sensors, WET Labs backscatter/fluorometers, dissolved oxygen sensors and photosynthetically active radiation sensors.

Seaglider is also used by the US Navy as part of their Persistent Littoral Undersea Surveillance (PLUS)

This view of a disassembled Seaglider shows the main internal components.



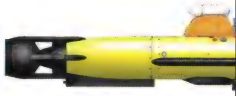
The main components of a Slocum glider. Note the highly modular construction which can be extensively customised.



This Google Earth map shows the trans-Atlantic crossing (US to Spain) of a modified Slocum glider called "Scarlet Knight". This was the first time an ocean glider had crossed an ocean. As an indication of the energy efficiency of the ocean glider mode of travel, a typical car would only travel about 10km on the amount of energy that this AUV used to cross the Atlantic. The crossing took 221 days from 27th April 2009 to 4th December 2009 (see project website at http://rucool.marine.rutgers.edu/atlantic/).

prototype system designed to surveil large areas of ocean for threats. The latest published information indicates that the PLUS system consists of five Seagliders and six REMUS 600 AUVs.

The REMUS 600s dive deep and collect information on enemy submarine threats. The Seagliders rendezvous



Above: the standard model of the Teledyne Gavia. Depending on configuration, it is typically 1.8m long, has a 20mm diameter, weighs 49kg in air and can travel at around 5.5 knots for about seven hours.

with the REMUS 600s, collect their data, surface and transmit the information. This persistent surveillance system is somewhat like a marine version of the US's ARGUS-IS and related airborne persistent surveillance systems – see www.siliconchip.com.au/Issue/2014/December

A Seaglider once held the record for the longest duration ocean glider trip – until that time – of over 5500km in 292 days, set in April, 2010. This record was later surpassed by the Wave Glider, described later in this article.

The Slocum Glider

Conceived by Douglas Webb, this UAV idea was first published as a futuristic vision in a science fiction article in "Oceanography" of April 1989 by Henry Strommel – see www.webbresearch.com/history_facilities.aspx

Slocum was named after the first person to single-handedly sail around the world. It is manufactured by Teledyne Webb Research in the USA and has long range and duration. It has a wide variety of sensors, including those to measure currents, turbidity and chlorophyll (and many others), plus hydrophones to listen to the environment.

According to Teledyne Webb Research, uses include improving ocean models, ground truth of satellite imagery, collection of water column data, improvement of data quality during greenfield operations, mapping currents for oil plume migration assessment (eg, DeepWater Horizon), low cost, rapid mobilisation for oil spill mitigation, pipeline monitoring, marine mammal awareness and real-time current monitoring during equipment installation, to stay compliant with current laws and environmental regulations.

Slocum's overall dimensions are 1.79m long x 1.01m wide (wing-tip to wing-tip) x 0.49m in height. The actual hull diameter is 0.22m. It is

made of carbon fibre and weighs 52kg. Its maximum depth is 1000m. It has RF and acoustic modems plus Iridium and ARGOS satellite communications. Its typical speed is 35cm/s or 0.68 knots and an optional propeller drive is available. The Slocum Glider was the first ocean glider to make a trans-Atlantic crossing.

Apart from civilian users, the US Navy also uses Slocum. Lt. Cmdr Patrick Cross of the US Navy said that the Navy "use(s) these to characterise the ocean. They're equipped with sensors that can give us salinity and temperature versus depth, and from that we can get sound speeds. We can feed that data into our MODAS [Modular Ocean Data Assimilation System], run by the Naval Oceanographic Office, and that provides a picture that we provide to our submarines". Slocum has also been launched and retrieved underwater by US Navy submarines.

Surprisingly, of the numerous options available on the Slocum Glider, one of the power sources offered is a battery pack that contains up to 360 "C" size alkaline cells. That would have to be a record for the largest number of "C" cells assembled into a single battery pack!

On alkaline batteries, the glider has a range of 600-1500km and 15-50 days duration; on lithium batteries the range is 4000-6000km and the duration 4-12 months.

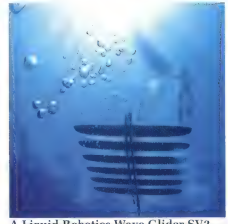
You can get an idea of the options and customisability of the Slocum G2 Glider if you look at the product catalog at www.webbresearch.com/pdf/G2_Product_Catalog.pdf and follow the section on "Build Your Slocum Glider". The operators manual can be viewed at www.bodc.ac.uk/data/documents/nodb/pdf/Slocum_G2_Glider_Operators_Manual_January_2012.pdf

Looking for algae on the underside of Antarctic ice

Another AUV project with Australian involvement is the study of algae growth underneath Antarctic sea ice. This is important because this growth represents the beginning of the Antarctic food chain. Scientists at Denmark's Aarhus University along with collaborators at the University of Tasmania used an Icelandic-made Teledyne Gavia AUV to scan beneath Antarctic sea ice, measuring light levels with a radiometer to determine where algae was most likely to grow.

Australian scientists modified the vehicle to look upwards and record light levels beneath the ice, contrary to its normal mode of operation of looking down at submerged objects (such as pipelines), looking at bottom sediments and looking for lost aircraft such as AirAsia QZ8501.

The Australian Maritime College at the University of Tasmania has received substantial funding to develop AUVs capable of exploring for hundreds of kilometres under sea ice. The proposed AUV will exceed the capability of the Teledyne Gavia which was capable of travelling 20-30km – see www.utas.edu.au/latest-news/utas-



A Liquid Robotics Wave Glider SV2, along with a support diver in Hawaii. On the surface is the "float" attached by a tether cable to the "sub" unit.

The float component of a Wave Glider (named "Fontaine") in rough seas. This was one of two gliders that headed for Japan while two others headed for Australia as part of the PacX challenge. Note the solar panels and various antennas.

Building Your Own Autonomous Underwater Vehicle

OpenROV (www.openrov.com/) is a tethered ROV (remotely operated vehicle) and is an open source project which could get you into the world of undersea exploration. A kit is available for purchase from the website for around US$900 which is roughly comparable to the entry cost for a higher-end UAV (unmanned aerial vehicle) – see video at "OpenROV v2.7 Video" https://youtu.be/35JhmbqvvW4

OpenAUV (http://openauv.org/) draws from the initial work of OpenROV and aims to develop designs for an open source AUV that can be used by hobbyists, students and scientists.

RoboSub is an annual competition established by the Association for Unmanned Vehicle Systems International (AUVSI) Foundation and the US Office of Naval Research (ONR) to advance the development of AUVs and is open to high school and university students from around the world – see www.auvsi-foundation.org/foundation/competitions/robosub/ The competition is held every year in San Diego.

The BumbleBee AUV team is a competitor at RoboSub (see www.bbauv.com/)and a video of their latest craft ("Bumblebee Robosub 2015 Video") is at https://youtu.be/Vvsl2vGhfD

Note that building AUVs or ROVs is significantly more difficult than building UAVs (unmanned aerial vehicles). Waterproofing everything is difficult and unlike when a UAV crashes, where you can usually see what happened and recover the pieces, an AUV just disappears into the water!

A simpler alternative to underwater vehicles for hobbyists is robotic sail boats and robotic boats. Another option – if you are really keen – is to buy a basic entry-level commercial ROV system such as the VideoRay Scout Remotely Operated Vehicle (ROV) System which can be purchased for around US$4800 – see http://shop.videoray.com/shop-front#!/p/39381588/category=0

A somewhat battered Wave Glider float and "sub" on display in Sydney after its world record long distance trip from San Francisco to Australia.

homepage-news/new-autonomous-underwater-vehicle-facility-to-help-drive-the-robotic-age-of-antarctic-exploration

Liquid Robotics Wave Glider

This unusual two-part AUV consists of a "float" about the size of a surfboard that contains solar panels, sensors and communications and control electronics. Then, tethered to the float about 7m below the surface is a "sub" or propulsion platform, to exploit wave energy to drive the UAV forward.

The "sub" has a series of hinged wings that rotate to a position angled forward (like "/") when the sub is pulled upwards by the float as it encounters a wave, causing the sub to move forward. As the sub subsequently descends, the wings rotate to a rearward facing position (like "\") and the glider again moves forward. For a video of this process see "Wave Glider Technology" at https://youtu.be/xflq9nQ_m2A

PacX was established by Liquid Robotics to send four Wave Gliders across the Pacific from the US to both Japan or Australia, in a competition to see who would make the best use of the data collected on the voyages. The voyages started in San Francisco in November 2011 and one glider, "Papa Mau", arrived in Australia in November 2012 and the other, "Benjamin", in February 2013.

Benjamin was recognised by the Guinness Book of Records for the longest journey of an autonomous surface vessel (despite being classified as an AUV). It travelled 14,703km, surviving shark attacks, severe weather and currents, arriving near Bundaberg.

The Wave Gliders in the PacX challenge each contained a fluorometer to measure such things as turbidity, dissolved organic matter and chlorophyll, a weather station, a sensor to measure water conductivity, temperature and salinity, a dissolved oxygen sensor and a wave sensor.

Solar-powered Remote Monitoring System (SRMS)

The SRMS (also known as the SAUV II) is a long endurance AUV that recharges its batteries via solar panels when it surfaces but is capable of diving to 500m. It has a number of com-

How AUVs Navigate

AUVs can obtain accurate position fixes using GPS on the surface but GPS and other radio signals are rapidly attenuated underwater. So when below the surface, AUVs use some or all of the following: a digital compass, an Inertial Measurement Unit (IMU), a Doppler Velocity Log (DVL), pressure and depth sensors and a sound speed sensor. Note that in polar regions, magnetic compasses are not effective.

A Doppler Velocity Log is a device which uses a series of three or more ultrasonic beams in the x, y and z directions that are reflected from the sea floor or by microscopic particles in the water (such as plankton) to provide estimates of a vehicle's velocity in relation to the sea floor or the water.

If an AUV is on an extended mission, such as an Ocean Glider which regularly surfaces over many months, it will use GPS to confirm its position and correct any navigational error. More accurate navigation such as for mapping requires an Inertial Navigation System (INS) using laser or fibre-optic ring gyros. An INS will contain an IMU as one of its components.

Long, Short and Ultra-Short Baseline acoustic positioning systems are also used. In Long Baseline systems, acoustic beacons are placed on the sea floor at known positions. An AUV or other underwater device interrogates the transducers and they respond with an acoustic signal. Based on the round trip travel time from three or more transducers and by using triangulation, the position of the AUV can be determined.

In Short and Ultra-Short Baseline systems no sea floor transponders are needed as these are attached to a surface vessel. In Short Baseline, the transducers are at a spacing of tens of meters so a large vessel is needed. In Ultra-Short systems, all three sensors are in one transducer head and phase differences between the different transducers are used to determine the AUV's location.

As an example of the accuracy achievable for navigation in underwater mapping operations, the Monterey Bay Aquarium Research Institute near San Francisco report that their Dorado-class AUV (named the "D. Allan B") can achieve a real-time accuracy of 0.05% of the distance travelled, with a 50% chance of an accrued navigational error of 5m after 10km of travel and a 1% chance of the error being more than 13m. After post-processing of navigational data, the relative navigation error is less than 3m, so the accuracy is comparable with civilian GPS.

Acoustic modems are available to transmit data between a surface vessel and an AUV. However, the data rates are relatively slow, such as 31.2kbit/s over 2000m in favourable conditions, 13.9kbit/s over 3500m, 9.2kbit/s over 6000m and 6.9kbit/s over 8000m.

munication options, can carry a payload of 25kg and can travel at 1-2 knots.

Because this vehicle uses a propeller, it is said to have better and more precise directional control than a glider. Typical applications are water quality monitoring, oceanographic measurements such as turbidity, temperature etc, fisheries management, marine environmental monitoring, resource protection, water reservoir mapping, internal waves and shear measurement, gas seepage detection, current profiling and sporting safety (eg, for yacht races).

One such AUV, the Tavros #2, even has its own Twitter account – https://twitter.com/tavros02 or @tavros02 – and, in 2012, was sending tweets with its location.

REMUS 100

The REMUS 100 (Remote Environmental Measuring UnitS) is a compact AUV that can be used down to 100m. It is built by Hydroid, a division of the Norwegian company Kongsberg Maritime, for such applications as hydrographic surveys, mine countermeasure operations, harbour security operations, environmental monitoring, debris field mapping, search and salvage operations, fishery operations, scientific sampling and mapping.

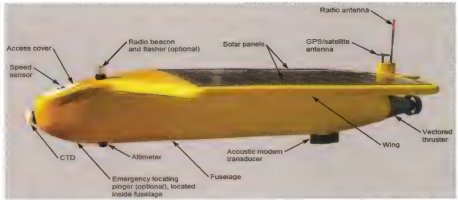
A typical REMUS 100 weighs 38kg, is 19cm in diameter, 160cm long, has a duration of 8-10 hours and a speed of up to 2.3m/s or 4.5 knots. The military version of REMUS is called "Swordfish" and is used by several navies around the world, including Australia, Belgium, New Zealand, Norway and the United States.

For a video of the Royal Australian Navy using this AUV (or presumably the civilian version in this case as it is called REMUS) see http://video.defence.gov.au/play/txZ29wczovD-kNpkQw7PIHON01uH0GdM or just Google "team remus in solomon islands defence".

Finding crashed aircraft

REMUS 6000 AUVs were used in the fourth search for the flight data recorders from Air France Flight AF447 which crashed into the Atlantic Ocean in June 2009 but was not found until May 2011.

AUVs have also been used in the search for the wreckage of Malaysian Airways MH370 which disappeared on 8th March, 2014. This is possibly the biggest maritime search in history and is the most expensive. The Australian Transport Safety Bureau (ATSB) is coordinating the search for MH370.



The SAUV II from Falmouth Scientific, Inc. This long-endurance AUV recharges its batteries using solar panels whenever it's on the surface and is capable of diving to 500m.

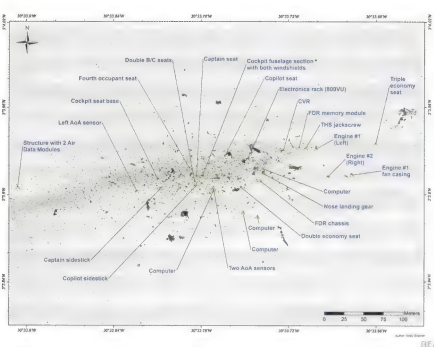
This photo shows one of three REMUS 6000 AUVs used to search for Air France Flight AF447 which crashed into the Atlantic Ocean in June 2009.

When this aircraft originally disappeared and Australia started the search, the most important thing was first to identify the likely area of the crash and then search for pings from the flight data recorder and the cockpit voice recorder. The search for the pings was undertaken with a towed device (not an AUV) borrowed from the US Navy and called the "Towed Pinger Locator 25". It was towed by the Royal Australian Navy's ADV Ocean Shield vessel – see www.navy.mil/navydata/fact_display.asp?cid=4300&tid=400&ct=4

After there was no chance of finding any pings due to battery depletion in the recorders, a search began of the sea floor for plane wreckage. A US Navy Bluefin-21 was operated from ADV Ocean Shield and employed to search 850 square kilometres of ocean in the vicinity of where possible pings were thought to have been heard. This AUV was used until May 29th, 2014.

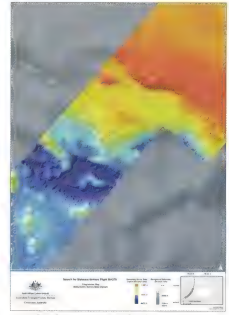
Australia then called for tenders for

The REMUS 100-S AUV. This "S" model is optimised for hydrographic and offshore surveys and is used by several navies around the world.



This debris field from Air France Flight AF447 was imaged using a side-scan sonar from an AUV.

The all-important flight data recorder from Air France Flight AF447. It was found at the bottom of the Atlantic Ocean by an AUV and recovered using a Remotely-Operated Vehicle.



Results from MH370 high-resolution bathymetric survey work in colour compared to previous low-resolution satellite data in greyscale. This survey work was done during the initial part of the search to generate an accurate map of the search zone. The data was acquired with a multi-beam sonar operating from a ship and represents a small part of the 60,000km^2 survey zone. (Image: ATSB).

a search operator to continue looking for MH370 and a Dutch contractor, Fugro Survey Pty Ltd, won the tender.

Fugro uses two towed (non-AUV) EdgeTech DT-1 towfish and a Kongsberg Hugin 4500 AUV. The AUV is used to search areas that are difficult or inefficient for the towed systems to search.

Three Fugro vessels have been variously used in the search. There is the "Fugro Equator" for mapping with a multi-beam echo sounder, the "Fugro Discovery" and the "Fugro Supporter".

We asked the Australian Transport Safety Bureau how much the search was costing (eg, the daily costs) but they said that details of the contract with Fugro were "commercial in confidence". However, on May 13th this year, www.news.com.au said Australia's budget contribution over two years was $79.6 million. That represents a daily cost of around $109,000 for Australia's share alone. Malaysia is also paying for some of the costs.

Video of testing the Bluefin-21 on an unnamed RAN vessel is at http://video.navy.gov.au/play/xzYW1wc-zoedWuUqytR7Pw0PtCdCfjnLp or it might be easier to Google the term "Testing of Bluefin-21 Autonomous Underwater Vehicle Navy"

Videos On Wave Glider

- "PacX: San Francisco to Sydney" https://youtu.be/AobmMjgKktY
- "Schwimm Roboter Wave Glider Von Liquid Robotics.mp4" https://youtu.be/Ulkwt_pHWqs
- "James Gosling on Wave Glider autonomy" https://youtu.be/BVjnY-u6aBFk and "Robot Swims 9,000 Miles From San Francisco to Australia" https://youtu.be/Ti8_Oy9GzNU

Military AUVs

As of 2014, military applications accounted for 60% of AUVs produced and demand by 2018 is expected to increase by 40% compared to the 2014 figures.

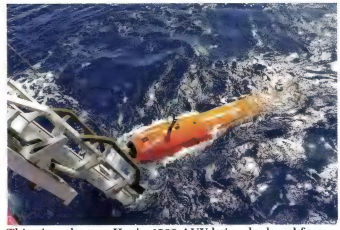
As with other AUVs, military AUVs have limitations based on the available battery power and the communications data rate. Also, as with any underwater acoustics (as might be used by sonar sensors employed to look for enemy targets), acoustic transmission through water is a lot less predictable than radar through air. This imposes limitations on sensors and acoustic data links.

Note that many sources refer to military AUVs as Unmanned Underwater Vehicles (UUV), as this is the military term for an AUV.

Knifefish is a military AUV designed to operate as a mine sweeper and to specifically replace the US Navy's trained mine-sweeping dolphins and sea lions of the Marine Mammal Program which will be wound up in 2017 after 50 years of operation. The robot is designed by Bluefin Robotics and General Dynamics and is based on the civilian Bluefin-21, the AUV involved in searching for MH370. It is scheduled to enter active service in 2017.

Knifefish is a torpedo-shaped design around 6m long, 0.5m wide and weighing 770kg. It is propeller-driven and uses lithium ion batteries, allowing it to operate on missions as long as 16 hours. It uses synthetic aperture sonar

US Navy operators with a Bluefin-21 AUV on-board the ADV "Ocean Shield". This AUV can operate at depths of 4000-6000m for 16 hours at a time and was initially used in the search for Malaysian Airlines MH370. (Image: US Navy).



This view shows a Hugin 4500 AUV being deployed from the "Fugro Discovery". This UAV was also used in the search for Malaysian Airlines MH370 off the Western Australian coast. (Image: ATSB).

to search for mines which it recognises from an on-board database. The locations of these mines are marked for later destruction by the combat vessel operating the Knifefish.

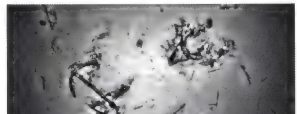
Legal & moral issues

Just as there have been legal and moral issues with respect to Unmanned Aerial Vehicles (UAVs) which have attracted legislative action, there are also issues to be considered with respect to AUVs. Among such questions are who is responsible if the machine is involved in an accident? Might it be the programmer who created its navigation algorithms, the owner or the operator and do the normal maritime laws apply to the operation of AUVs? What if one washes up on a shore or what if someone just grabs one out of the water (is that piracy)? What if they deliberately or accidentally cross international boundaries and what if an AUV is used to commit an offence?

How autonomous should AUVs be allowed to become? Will military AUVs be able to engage targets without a "human in the loop"? Such questions are already being asked about land-based autonomous military robots.

Already UAVs have been used by criminals to fly drugs from Mexico to the United States (and presumably elsewhere). It is also known that criminals have used both manned private submarines and AUVs to deliver drugs to the USA.

While a towed vehicle rather than an AUV, this EdgeTech DT-1 named "Dragon Prince" is being used in combination with an AUV in the search for MH370. It is pictured onboard the "Fugro Discovery". (Image: ATSB).

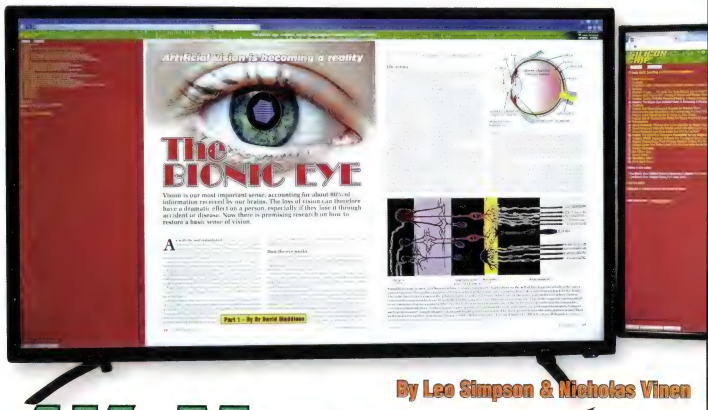


Incidental discovery of an as yet unknown vessel during the search for MH370. This image, dated 11th May 2015, was taken by a Kongsberg Hugin 4500 UAV launched from the "Fugro Supporter" and is likely to be the wreck of a 19th century merchant sailing ship. The wreck is at a depth of 3900m and the most clearly identifiable feature is the ship's anchor. (Image: ATSB).

Conclusion

AUVs have demonstrated an ability to operate for extended periods of time, including the ability to make trans-oceanic crossings. AUVs are much more cost-effective than traditional surface ships and AUV costs will inevitably continue to decrease.

It is expected that more and more environmental monitoring will take place as well as more exploration of the ocean bottom. In addition, there is a major role for military AUVs in surveillance and mine and terrorist counter-measures which may serve to make our world a safer place. SC



By Leo Simpson & Nicholas Vinen

4K Monitor Shoot-Out

Fancy a big ultra-high definition (4K) monitor for your PC? The good news is that 4K TVs are becoming cheaper and they are now an interesting proposition for anyone who is frustrated with using two or more monitors with a PC.

BACK IN June 2013, we compared the performance of an LG 32-inch smart HD TV with a Dell 30-inch monitor. The LG TV was cheaper and used less power than the Dell monitor but the latter has considerably higher resolution. But technology has marched on considerably in two years and now 4K TVs are on the market and getting cheaper.

My PC set-up in the SILICON CHIP office has two monitors, a Benq 24-inch HD 16:10 model and an Acer 16:9 (1920 x 1080 pixels). The Benq is used in Landscape mode while the latter is used in Portrait mode which is good when looking at emails, many websites where you tend to scroll down interminably and long documents. It is great to have the extra screen area which two monitors allow and you can have three or four windows open at any time and rapidly drag and drop stuff from one window to another.

So that is good but there is a problem with multiple screens and that is apparent when you are moving the mouse from one screen to another – the mouse tends to get lost somewhere off-screen and then there is a lot of frantic jiggling of the mouse until it reappears again, accompanied at times by "unseemly" language.

While this is a minor gripe, the recent release of a cheap 42-inch 4K monitor under the Bauhn brand by Aldi stores made me think again. Now I cannot see why anyone would bother buying a 4K TV for watching TV or

The above view shows the two units side-by-side, with the Bauhn 42-inch 4K TV set at left and the Philips BDM4065UC 40-inch monitor at right. There's not much difference between them in terms of picture quality.

Blu-ray DVDs. Sure, they do a good job of up-scaling normal HD signals from Blu-ray etc but most people simply would not be able to pick the difference at normal viewing distances; even 20:20 vision or better will not resolve it (and yes, there are 4K Blu-ray players but very few discs are available at present).

But if you are going to use a 4K TV set as a PC monitor, that is an entirely different proposition. Your viewing distance is typically less than one metre and if you are looking at a large screen, normal HD leaves a lot to be desired. In fact, that was the main difference with our previous monitor shoot-out. There is no avoiding the fact that the picture detail in a 30-inch 2560 x 1600 monitor is clearly superior to that of 1920 x 1080 pixels on a 32-inch screen.

Clearly, if you were considering a 42-inch screen, standard HD at 1920 x 1080 pixels would be woeful and even 2560 x 1600 would be less than ideal. 4K, at 3840 x 2160 pixels (ie, twice that of normal HD), is what you want.

When Aldi stores recently had a one-day special on their Bauhn ATVU42-515 42-inch 4K TV for $499, I initially didn't give it a second glance, because I was echoing the above thought: why would you want one for watching TV? Then I thought about the potential advantages of using it as a large PC monitor and decided to hot-foot it down to the nearest Aldi store – I got the last set. At that price, they were certainly popular.

But hooking a 4K monitor to a PC is pointless unless the PC's video card can deliver a 4K signal. For that you will need an HDMI output; preferably HDMI 2.0 but HDMI 1.4 will suffice (we'll get to the details later). And while my computer did have HDMI outputs, its maximum output resolution was normal HD at 1920 x 1080 pixels. So a better video card was required.

After some research, a Gigabyte GeForce 750 GTX video card was purchased and installed in the computer. The Gigabyte card comes with two HDMI outputs and one DisplayPort. The Bauhn set does not have a DisplayPort input so you have use one of its HDMI inputs.

Setting up the Bauhn TV was quite straightforward and in the result, the new set takes up only slightly more desk space than my previous 2-monitor set-up with one set in Landscape and one in Portrait mode. However, the total screen area is increased by a factor of about 1.5 and the pixel size is a lot smaller.

As with the 32-inch smart TV referred to in the June 2013 article, one the first things to be done with the Bauhn 42-inch TV is for it be set so that it shows no over-scan of the picture. You need to set the aspect ratio to "Just Scan" which means that you get exactly the full picture on the screen. You will find that this is necessary because otherwise part of the task bar at the bottom of the screen is liable to disappear.

I should mention the Bauhn set's menus and the remote control. First, the remote control is poor. You must aim it precisely at the right-hand bottom corner of the screen otherwise it simply won't respond. The buttons sometimes jam and then are you left wondering why the (expletive deleted) set won't respond to any other buttons being pressed.

The menus are clunky; yep, just clunky and the options for adjusting the picture are quite limited. There is no adjustment for gamma and while you can adjust for brightness, contrast and RGB saturation, you cannot select a particular colour temperature.

Having said that, the resulting picture is really quite good and of course, you can go into the settings for the video card itself. And while the viewing angle for a PC monitor is less important than for a TV, viewing the picture off-axis is pretty good; we assume that the LCD panel is an IPS (in-plane switching) type.

Overall illumination from the LED back-lighting looks reasonably uniform on normal video program but when you have a uniform white screen, you can see the brighter vertical stripes where the backlighting LEDs are present. In most applications, this should not be a problem.

The pixel pitch is very impressive at 104 PPI (pixels per inch) horizontally and vertically, ie, the pixels are square. Unless you peer at the screen very closely or use a magnifying glass, you are simply unaware of the pixels. Compare that pixel count with the 91 PPI count of the above-mentioned Acer 24-inch monitor!

And if you compare the Acer 24-inch 16 x 9 monitor with the Bauhn 42-incher, the latter is three times larger. In practice though, it seems even larger because you can easily have

Think a 24-inch monitor is big? Not any more – the 24-inch Acer FHD (1920 x 1080) monitor at left is no match for the Bauhn 42-inch UHD (3840 x 2160) TV (right) when it comes to screen real-estate. As well as its much larger screen size, the Bauhn set also has much better resolution, making text easier to read.

four, five or six windows open on the screen and while there may be some overlap, you can very easily jump from window to window while they still all remain visible.

Admittedly, setting up a "tiled" display in Windows can be a bit unwieldy but it works and the fact that you don't ever lose the mouse as you move around that large screen is a boon; no more frustration when moving across a two-screen set-up.

Latency and mouse response

There was bound to be a drawback, of course, and it didn't take long for that to become apparent – latency and mouse response. In our June 2013 article, we remarked that when we had Windows so that both monitors showed the same picture (duplicate mode) the mouse responded normally on the computer monitor but was "floaty" and vague on the smart TV and this has to do with the internal video processing.

The solution to the floaty mouse problem is to set the smart TV into games mode. When that is done, the mouse responds precisely when it is moved, as it should. Sadly, the Bauhn ATVU42-515 42-inch 4K TV is not a "smart" TV and it does not have anywhere in its on-screen menus where you can set it into games mode. That is most unfortunate, since it means that mouse control is inevitably less precise than it should be. You can play around with mouse settings in the Windows control panel but the result is still less than optimum.

We have been in contact with the distributor for Bauhn TVs (www.tempo.org) but they were not able to help. Still, we are hopeful that a software update (performed via the rear USB socket) will fix the problem in future.

In the meantime, while the mouse response is adequate (barely), the lack of a games mode really means that the Bauhn TV is not suitable for games applications. That is a pity because in most other respects, it is a fine performer.

Of course, games addicts will probably turn up their noses at the Bauhn TV in any case. Even though it displays a fine 4K picture, its refresh rate appears to be a maximum of 30fps (frames per second). This is really not fast enough for a lot of games with fast video action. I should also note that the latency of the screen is also evident in response to a keyboard. If you type at a fast rate, you will notice it.

Finally, I should mention the aspect of power consumption. This is stated quite vaguely in the Bauhn specifications as less than 100 watts. In practice, it is typically around 80 watts with a mains input voltage of around 235-240VAC. On standby, it drops to around 285 milliwatts.

However, there is one setting you will want to make, if you are going to take advantage of its low standby consumption when your computer goes to sleep. Unless you set the Bauhn to a sleep mode with 10 minutes (the minimum setting) it will continue to draw 80W, even though it may be displaying "no signal".

Overall conclusion: the picture is generally good but a software upgrade and an improvement to the picture menus could make a major difference to this Bauhn set.

An alternative way

Nicholas writes: when Leo plonked the 4K TV on his desk, it was a great affront to my status as the large-screen guru of the office. My 30-inch Dell monitors suddenly seemed inadequate

by comparison and clearly I had to do something about this. So in the spirit of one-upmanship I decided that I too needed a 4K monitor; only mine had to be better than his.

While I appreciate that TVs are cheaper than monitors, they generally are not the best choice for various reasons. Not being a total cheapskate, once I discovered that similarly-sized 4K monitors are available for just over $1000, I decided that was the way to go. After a little research, it seemed that a Philips BDM4065UC 40-inch monitor would restore my status and I placed an order right away (at company expense, of course!). A courier dropped it off later that week.

At 100.5cm diagonal (around 40 inches), it's a bit smaller than the 42-inch Bauhn TV but you would be hard-pressed to tell the difference unless they were side-by-side. They are both the same resolution, ie, 3840 x 2160 pixels which is often referred to as 4K but is more accurately described as "UHD-1" (cinema 4K is 4096 x 2160 and does not have a 16:9 aspect ratio).

Unlike the Bauhn TV, the Philips monitor has a DisplayPort input (as well as two HDMI inputs, one mini-DisplayPort and one VGA). Currently, DisplayPort is really the only way to get a 4K picture with a 60Hz refresh rate. And that's the minimum you need for fluid motion. It's vital for games but any other interactive software (eg, PCB layout ECAD packages) will also benefit from it. Even office-type software is easier to use with a mouse cursor that responds more-or-less instantly.

With a 60Hz refresh rate, the response time is going to be somewhere around 1s ÷ 60 = 16.6ms but inevitably, there is some extra delay between the data arriving at the monitor and it appearing on the screen. With a purpose-built monitor, this delay will be minimised whereas with a TV, it could be substantial. As a result, when switching between using Leo's computer and mine, the experience is like jumping from an old Holden into a 2015 Falcon XR8!

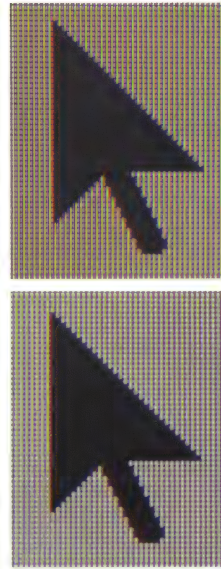
Image quality

The Philips monitor also appears to have more even display brightness; on a blank white screen, you can clearly see vertical white stripes on the Bauhn TV. While the Philips monitor doesn't have perfectly even illumination (few screens of this size are likely to), it isn't bad. It even comes with a calibration certificate which shows an ~5% variation in brightness across the display. You don't normally notice it.

While colour rendition on both displays is adequate, I think it's slightly better on the Philips monitor and you certainly have a lot more scope for adjustment through the on-screen menus. Its calibration certificate also indicates colour uniformity across the display with a specified maximum deltaE of 4. That's good but not great.

One really noticeable difference between the two is that the Philips monitor uses a VA (vertically aligned) LCD panel rather than the IPS (in-plane switching) of the Bauhn. VA screens have a much higher contrast ratio than IPS; in this case an amazing 5000:1. But they don't have anywhere near as good viewing angles. In other words, once you're looking at the display slightly off-axis, there is a reduction in brightness and a slight colour shift.

You can really notice the high contrast as black areas of the screen appear to be part of some great abyss* which sucks in all visible light, forming an inky dark pool. But if you sit as close to the screen as I do, you will notice a drop-off in brightness in areas near the edges and especially the corners of the screen, as a result of the less-than-ideal

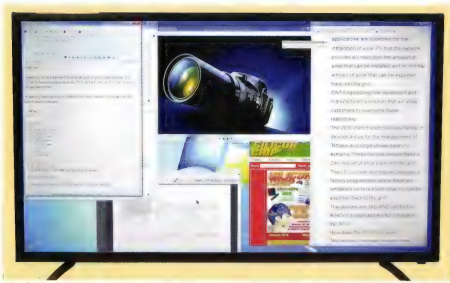


These two greatly-magnified views show the pixel structure of the Bauhn ATVU42-515 42-inch 4K TV (top) and the Philips BDM4065UC 40-inch 4K monitor. There's nothing between them when it comes to resolution.

viewing angle. Having said that, with a screen this size, you will probably find yourself moving your head around a bit to see what's in the corners anyway, which reduces this effect (*note: while looking into the abyss, the abyss may also look into you but only if you have a webcam with poor security).

So on balance, the comparison between VA and IPS is fairly even. They both have their advantages. I do like the very small bezel on the Philips monitor compared to my Dell 30-inch model. It looks more modern and you notice it less.

One thing to note is that both panels (ie, this one and the Bauhn) suffer from the lack of a proper anti-glare coating.



The big advantage of a large screen (42-inch) monitor is that you can have lots of windows open a and displayed on-screen at the same time, making it easier to jump from one to the other.

Eyesight not as good as it used to be? Using the Bauhn UHD TV as a large-screen monitor makes it much easier to manage email, especially if you have lots of folders for archives, etc. Note the slightly uneven lighting across the display.

I understand that touch-screens need to be somewhat glossy but all that will happen if you touch this screen is that it will leave smudged fingerprints and I just can't understand why anybody would prefer a reflective screen in this case. It simply reflects too much of what's in front of it, especially if the room is well-lit. It doesn't ruin the experience but it is clearly sub-optimal.

User interface & power consumption

This Philips monitor has a much better control system than any other I've used. That's because rather than an inscrutable array of poorly-labelled buttons, it has a 4-way pushbutton joystick at the back. It's in a position that you can easily reach when sitting in front and because you don't have to guess which way is up/down/left/right, the menu system is easy to navigate.

Pressing and holding the joystick for a few seconds switches the screen on and off. When off, it only uses about one quarter of a watt. If you don't turn it off and just let it go into standby by itself, power consumption is still under half a watt, which is also very low. Unlike the Bauhn TV, which has a sleep delay, the Philips monitor goes into standby as soon as the computer does.

This is my first large LED-backlit monitor and it uses a surprisingly small amount of power at just 56W (measured). That's with a moderate brightness, more than adequate for indoor work with an open window nearby. It's quite a bit less than Leo's TV and substantially less than even one Dell 30-inch monitor, let alone the two I was using before (at more than 100W each!). It barely gets warm.

Driving it

I'm using the same GeForce GTX 750 video card as Leo. We bought these because they have a relatively recent HDMI implementation and we hoped that it would allow 4K @ 60Hz. Unfortunately, information on which cards support which version of HDMI is extremely scarce and we subsequently discovered that few if any video cards and monitors support this mode over HDMI, even though the HDMI 2.0 standard which supports it is around 18 months old now.

As a result, DisplayPort is really the only option for driving a monitor like this and that's likely to be the case for some time. The monitor comes with a range of cables, including HDMI, DisplayPort and mini DisplayPort, so once you have the right video card installed, setting it up involves little more than connecting them together.

There's just one trick: by default the Philips BDM4065UC uses DisplayPort version 1.1 and so will only run at 4K/30Hz. You have to go into the on-screen menu and enable DisplayPort version 1.2a and then the 60Hz option will appear on your computer. I was a bit nervous until I discovered this!

Other features

The Philips monitor has a number of other features which I'm not using but that may be of interest to others. For a start, you may notice that the 3840 x 2160 resolution is exactly twice as many pixels wide and tall as full HD (1920 x 1080). The monitor actually allows you to use multiple signal sources (up to four) to drive different sections of the screen.

So, for example, if you had it hooked up to a desktop computer but occasionally brought a laptop home from the office, you could plug the laptop into the same screen and use both computers on it simultaneously.

As well as "tiling" the displays, you

can also view them as picture-in-picture. Oh, and I should mention that like Leo's TV monitor, this monitor also has down-ward firing speakers which are normally driven from the audio signal supplied from the computer over the HDMI or DisplayPort cable, although you can simply feed in an analog signal if you prefer. Sound quality is . . . um . . . poor. But it's good enough to alert you to the arrival of new emails or annoy you when you visit a web page with auto-play video ads.

The monitor stand is a very basic affair and is not adjustable but you really don't need it on a display this big. It takes up most of your field of vision and with a regular desk, it will be at about the right height anyway.

Smaller 4K monitors

For me, the pixel density of a 40-inch 4K monitor is about ideal. It's similar to the pixel density of the 30-inch Dell monitors (at 2160 x 1600) or a 22-inch monitor at 1920 x 1080. You can see the pixels if you look hard enough but they aren't really obvious. However, if you do a lot of photo editing, desktop layout or other similar jobs, you may prefer a higher pixel density which approaches that of a high-resolution printer.

The Philips BDM4065UC has a pixel density of 4.4 pixels per millimetre which equates to 111 PPI. By comparison, the 4K Dell UP2414Q at 23.8 inches has 7.3 pixels per mm or 185 PPI. And this Dell monitor has a high degree of colour accuracy; it's an IPS panel with an anti-glare coating. The price is similar to the Philips display, so if you have a small desk or simply want a very high pixel density, this might be a good choice.

Other options include the Dell P-2715Q at 27 inches (6.4 PPmm/163 PPI) and the 31.5-inch Dell UP3214Q (5.5 PPmm/140 PPI). It just depends on what size suits you and how important number of pixels is compared to the display area. As stated earlier, for most software, overall screen area matters more than pixels (although more pixels are usually better).

Other manufacturers, including LG Asus and Samsung offer similar products. However Philips and Dell appear to offer the best value at the moment.

Conclusion

Unless you absolutely need the best colour rendition or can't fit a large display on your desk, the BDM4065UC is one of the best value-for-money large 4K displays available. And unless you simply can't afford the Philips, I wouldn't bother messing around with 4K TVs. It's just so much less hassle to get a proper monitor and the extra few hundred dollars are, in my opinion, well spent.

If you must use a TV instead, make sure it has a games mode before you buy it. Even so, you'll probably be relegated to the same type of purgatory as Leo, constantly chasing your mouse cursor as it jumps around the screen.

Finally, please don't anyone tell Leo that 5K monitors are now available. If he ends up getting one, outdoing him again might be very expensive!

The back of the Bauhn TVU42-515 42-inch UHD TV set carries the usual array of inputs and outputs, including three HDMI inputs, composite & component video inputs, two USB inputs, an antenna input and analog and digital audio outputs. There's also a VGA socket and an audio input socket.

This view shows the rear of the Philips BDM4065UC 4K 40-inch monitor. Unlike the Bauhn TV set, it includes a DisplayPort input (as well as the usual HDMI, USB and VGA inputs). In addition, the Philips monitor allows you to use multiple signal sources (up to four) to drive different sections of the screen.

Pricing & availability

The Philips BDM4065UC is available for $1000-1100 including GST plus P&P from online suppliers such as Scorptec (www.scorptec.com.au – Monitor Cat. BDM4065UC; GeForce 750 GTX Cat. GV-N750OC-2GL), Mwave (www.mwave.com.au – Monitor Cat. AB58995; GeForce 750 GTX Cat. AB58983). SC

Sens

We thought Allan Linton-Smith had designed the ultimate high fidelity build-it-yourself loudspeakers when he presented the "Majestics" back in June last year. But we were wrong!

Design by Allan Linton-Smith

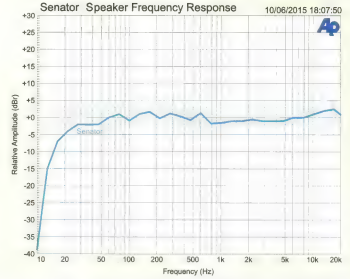
ational!

These look even better and sound amazing – but they're smaller and even easier to build. They compare more than favourably with "big name" speakers costing many times the price. We call them The Senators.

Words by Leo Simpson

How do Senator and Majestic compare?

We'll let the graphs tell the story: At left is frequency response for the Senator (dark blue) compared to the Majestic (light blue). As you can see, the overall response is flatter however the bass -3dB point is higher at ~25Hz compared to around 15Hz for the Majestics.
The centre graph shows the distortion plot at 1W. Mid-range distortion is very low for the Senator speakers although the smaller bass drivers result in higher distortion at lower frequencies compared to the Majestic. No surprises that treble distortion is similar as they use the same tweeter and horn.
And at right, like the Majestics, the Senator speakers have a similar but less peaked impedance curve. Note that impedance is above 8 ohms at all frequencies, although it may dip slightly below above 10kHz if the treble boost network is in-circuit. The upper bass impedance peak is around 80Hz, compared to 57Hz for the Majestic.



Did you lust after the Majestic loudspeakers described in our June 2014 issue? That massive 15-inch woofer and the Celestion horn tweeter gave very high efficiency, super power handling and staggering bass response down to below 20Hz. But now we present a somewhat less bulky loudspeaker system, still with high efficiency and high power handling but easier to build and even (gulp) better looking.

The Majestic loudspeaker certainly raised a lot of interest last year. Some readers simply did not believe that it has a linear response down to below 20Hz. "Not possible!", they said. On the other hand, no-one who built these loudspeakers has written to us complaining that it doesn't go down to 20Hz and below.

If you assess it on sheer performance, it must be one of the greatest loudspeaker bargains ever produced over many decades.

However, the Majestic design does have a number of drawbacks. First, there is no denying that it is B-I-G! And heavy; too big, too heavy and too imposing for most people's homes.

Nor is it particularly easy to build, even allowing for the fact that the cabinet is based on the readily available Kaboodle kitchen cabinets (from Bunnings hardware stores) which can provide a flawless finish.

Another problem was that the originally specified Etone tweeter horn and also the Etone 15-inch woofer have become unavailable and the only suitable alternatives are presently the much more expensive Celestion tweeter horn and Celestion 15-inch woofer.

That makes the Majestic much less attractive to any audio enthusiast with a tight budget.

So a number of readers asked us for a somewhat slimmed-down version of the Majestic, incorporating all of its desirable characteristics but smaller, better looking, easier to build etc etc...

Well, as much as we'd like to, the laws of physics simply do not allow us to produce a smaller loudspeaker system with the same high efficiency and frequency response down to below 20Hz.

But we have been quietly (actually, not so quietly!) beavering away to produce a very attractive alternative to the Majestic which we have called the Senator.

The woofer

It is based on a Celestion NTR10-2520D 10-inch woofer with a stated efficiency of 96dB/1W@1m and a power rating of 250W (AES).

By the way, that is not some "mickey mouse" rating that you see with some consumer audio equipment. This is the AES (Audio Engineering Society) rating which tests the speaker with continuous band-limited pink noise for two hours in free air (no baffle). That is a very stringent test and you can imagine how hot the voice coil and magnet must become during such a protracted test.

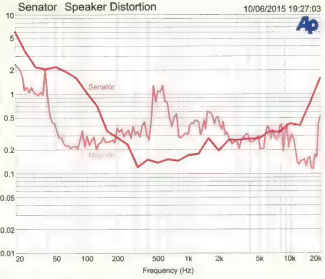
And think of the long-term stresses on the cone and its suspension.

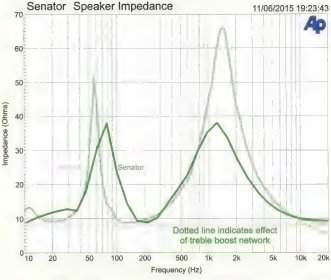
Incidentally, the voice coil is 64mm (2.5 inches), wound with copper-coated aluminium ribbon on a fibreglass former.

The magnet is not as massive as you might expect with such a high efficiency driver since it is a neodymium type and quite compact. In fact the overall mass of the Celestion woofer with its rugged cast alumininium basket is only 2.2kg.

Interestingly, as you can see in our photos of the drivers (page 35) the voice coil is ventilated to improve heat dissipation and improve linearity (since the air otherwise trapped behind the cone's large voice dust cap is not subject to large pressure variations by high amplitude signals).

The curvilinear cone is made of Kevlar-loaded paper, with a fabric roll surround. The loudspeaker's spider (which suspends and attaches the voice to the chassis) is particularly large at about 130mm in diameter, and together





with the specially treated roll surround, allows for large linear cone excursions.

And the tweeter

The specified tweeter is the same Celestion CDX1-1730 compression driver mated with a Celestion T1534 horn (as featured in the follow-up article on the Majestics in the September 2014 issue).

The crossover network PCB is the same as the Majestic but with slight component changes, to be detailed next month.

The specs

If you take a look at the specification panel for the Senator and compare it to the spec panel for the Majestic (page 24, June 2015), you will see that it comes pretty close. Sure, it does not have a flat response all the way down to below 20Hz but the response is only 5dB down at 20Hz and less than -3dB at 30Hz. That is a very good result from a 10-inch driver in a considerably smaller enclosure.

Note that the frequency response from 60Hz to 20kHz is very smooth and in fact, a little smoother than the original published response curves for the Majestic with the Etone horn (June 2014) or the Celestion horn (September 2014).

Not only that, the Senator's efficiency is only 2dB less than that of the Majestic and its power handling is only 1.6dB less, so this is capable of dangerously high sound levels – an estimated 119dB at a distance of 1 metre!

Mind you, we don't recommend anyone driving a finished Senator at such insane levels for any more than normal program peaks.

Unless the cabinet is strongly reinforced, there is no guaranteeing its integrity if subjected to extreme and continuous power levels up to 250W.

The 200W/channel ULD amplifier module in this issue is ideal for driving the Senator – pro-

Senator Speaker Specifications

Power Handling:	up to 250W RMS (AES standard, continuous pink noise)
Sensitivity:	95dB / 1 watt @ 1m
Frequency Response:	+5/-3dB 20Hz – 20kHz
Harmonic Distortion:	<2.4% 20-50Hz; (typically less than 0.5%)
Cabinet size:	340 (w) x 740 (h) x 433 (d) (mm)
Woofer:	Celestion NTR10-2520D 10"
Tweeter:	Celestion CDS1-1730 compression driver, mated with a Celestion T1534 horn
Crossover:	2-way first order (6dB/octave slope)

viding, that is, that you don't try to drive it at maximum power for even relatively short lengths of time. If you did, you'd probably damage your hearing, if nothing else. What didya say?

One the other hand, if you drove it with the modestly-powered Currawong valve amplifier, for example, it would still be capable of extremely loud volume levels in an average listening room.

Apart from being able to deliver very high sound levels, there is another advantage of the Senator's high efficiency of 95dB/1W@1m, compared to a typical high fidelity loudspeaker of maybe less than 90db/1W@1m (and sometimes less than 87dB/1W@1m) so that you are very unlikely to drive your amplifier into clipping on program peaks.

There just isn't the need to have the volume control turned well up.

That means the high dynamic range of modern sound recordings will be fully preserved, even if you are listening to the most boisterous symphonies or operas.

Gentle impedance characteristic

Another worthwhile advantage of the Senator is that it has a "gentle" impedance curve over the whole audible spectrum from 20Hz to 20kHz and nowhere does the impedance drop below 8Ω.

This in contrast to some loudspeakers which can have dips in the impedance curve well below 4Ω. The benefit of this gentle impedance curve is that it is very easy to drive for typical audio amplifiers and they will produce less distortion in the process, since distortion in all amplifiers increases as the loudspeaker impedance is reduced.

Cabinet features

As with the Majestic loudspeaker system, the Senator is based on the "Kaboodle" Flatpax Kitchen cabinet system, available from Bunnings Warehouses, so it will be locally available to everyone in Australia.

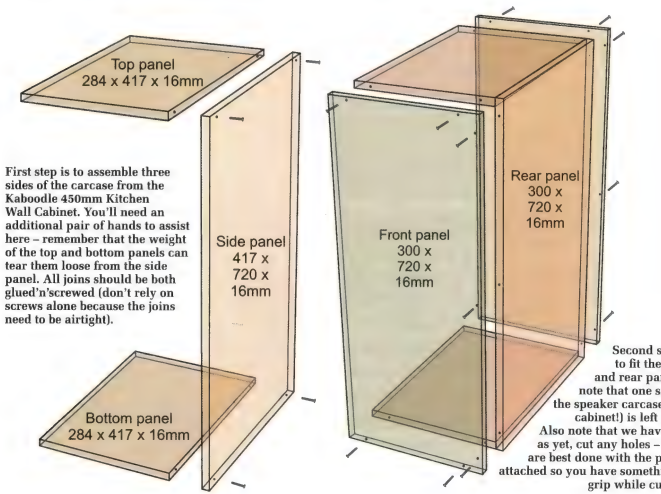
This system, which usually allows you to create your dream kitchen cabinets, is very easy to construct so you will get a very professional finish with the basic cabinet together with high quality thermoformed doors ... er, speaker baffles ... and sides imported from Germany.

So the speaker box is really a 450mm wide kitchen wall cabinet with the front door used for the two sides and a side panel for the baffle and top. Some simple modifications are required to put it all together.

The specific cabinet we used normally sells for a shade under $75 so for $150 (pair) you have the basis of a great speaker system. And the beauty is that every piece is cut 100% square (you only need to make a couple of cuts yourself to make them into speakers).

Most home-made speaker systems fail in the beauty department but you can build this one and get a perfect finish and a totally professional appearance and build it in a weekend...but if you want to keep your partner happy, you had better let the decorator of the house choose from the huge range of colours available.

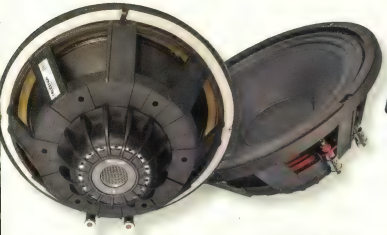
You could try a black piano finish or brilliant glossy



First step is to assemble three sides of the carcase from the Kaboodle 450mm Kitchen Wall Cabinet. You'll need an additional pair of hands to assist here – remember that the weight of the top and bottom panels can tear them loose from the side panel. All joins should be both glued'n'screwed (don't rely on screws alone because the joins need to be airtight).

Second step is to fit the front and rear panels – note that one side of the speaker carcase (aka cabinet!) is left open. Also note that we have not, as yet, cut any holes – these are best done with the panels attached so you have something to grip while cutting!

The Speaker Drivers We Used . . .



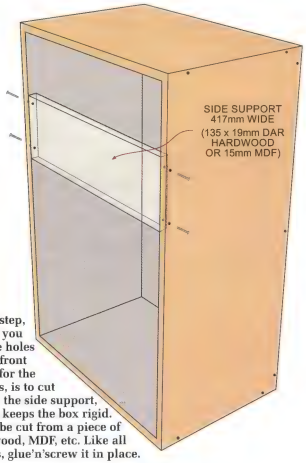
As mentioned in the text, the Celestion NTR10-2520D woofer used in the Senator is quite different to that in the Majestic – apart from the obvious difference in size (10 inches vs 15 inches).

While this size difference (and the smaller enclosure size) would normally be expected to have a major impact on bass response, we've gone to a lot of trouble to ensure this is not as significant as you might expect. In fact, we're pretty happy with the performance of the Senators!

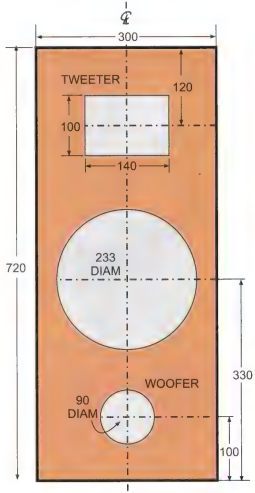
Of particular interest – and very obvious in the photo above left – is the vented voice coil, which improves both heat dissipation and linearity.

The Celestion CDX1-1730 compression tweeter mated with a Celestion T1534 horn, on the other hand, is exactly the same as that used in the *revised* Majestic speaker (September 2014).

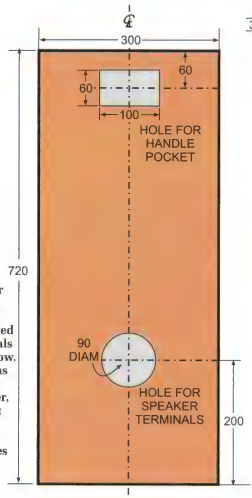
This change was forced upon us because of supply problems with the original tweeter but, as they say, every cloud has a silver lining: this driver/horn combination performs superbly in both the Majestic and Sentaor speakers.



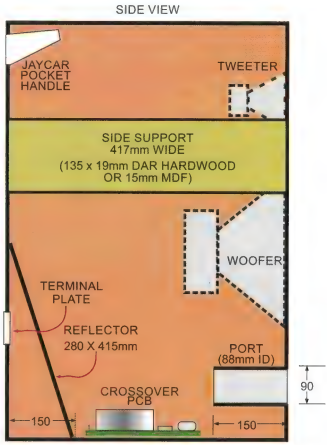
Third step, before you cut the holes in the front panel for the drivers, is to cut and fit the side support, which keeps the box rigid. It can be cut from a piece of hardwood, MDF, etc. Like all panels, glue'n'screw it in place.



Step four: speaking of the holes for the drivers, here's the cutting detail for the woofer, tweeter and port to be cut in the cabinet front panel. The same holes need to be cut in the Kaboodle dress panel; obviously this panel is slightly larger so refer to the diagram overleaf to get the correct dimensions. We don't fit the speakers until much later but the holes are best cut now.



Step five: similarly, the holes in the rear panel to house the handle and the plate-mounted speaker terminals should be cut now. Neither positions are particularly critical; however, the handle must have clearance from the top panel as it slopes upwards inside the box.



Step six: the reflector board (at bottom) is made from the Kaboodle shelf, glued into position as shown. Wires from the terminal plate will be routed around this piece.

white, or be really daring and go for "seduction red" in full gloss or the more conservative "Myrtle gloss".

If you want it all to match with some modern colour schemes you might even like to use "mocca Latte" and let the speakers blend into the background!

Many Bunnings outlets have samples of their finishes on display so you get to look and touch them before you decide.

If white is your colour, the Kaboodle in gloss white finish is immediately available at many Bunning's outlets but we decided that we must build a pair in "seduction red". These (as for some of the other colours) need to be ordered and will take about two weeks.

Construction

While the cabinet is based on a standard Kaboodle kitchen wall cabinet and dress panels, our method of construction is quite different from that normally used and as depicted in the instructions and the DVD that is available from Bunnings.

By all means look at those instructions and DVD because they give useful background info but then you should largely ignore it and follow the assembly diagrams in this article.

We are taking a kitchen wall cabinet which would normally be wide and shallow. We rotate it so that it is fairly narrow but deep, giving an enclosure which has a relatively small frontal area but is quite deep. That way, a pair of these speakers will appear to be less bulky and take less space in your listening room.

So what we are basically doing is building a box within a box. We assemble the standard cabinet "carcase" with one side missing. To take the place of the missing side, we put in a support panel.

We then cut the holes in what will be the front panel for the tweeter, woofer and bass reflex port. We also cut the holes in what will be the rear panel for the terminal plate and the hand-hold (very handy for lifting the rather heavy finished enclosure). The full procedure is outlined in the accompanying diagrams.

However, as you proceed, there are a few important things to keep in mind:

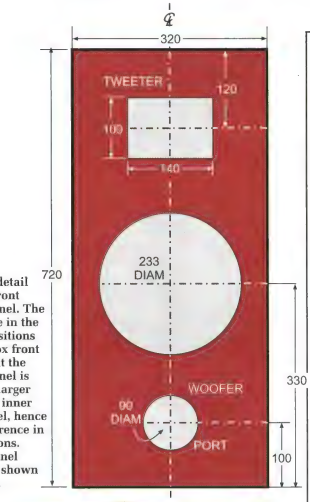
(a) Leave the protective plastic coating on the Kaboodle gloss dress panels until the enclosures are complete and all the hardware (speakers, crossover PCB etc) are installed. They'll minimise scratches and damage from any "oopses". Be especially careful not to drop screwdrivers or other tools onto the dress panels.

(b) All joins must include a bead of silicone sealant to ensure they are airtight. We used bathroom caulking compound which has very good adhesive properties. It is good because it allows you move panels slightly to get the position just right but once it has set, it is extremely strong.

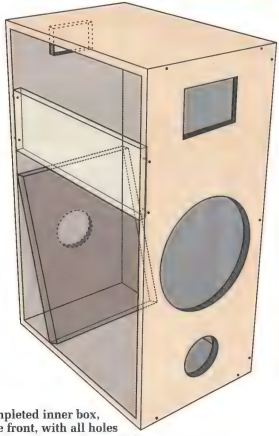
After all, a similar method is used to assemble aquarium tanks.

Too much sealant is better than not enough – but be careful to clean up any excess as you go. The longer you leave it, the harder it will be remove.

(c) Openings for the woofers and tweeters need to be cut in the 'door' panels. These are best cut from the non-glossy



Cutting detail for the front dress panel. The holes are in the same positions as the box front panel but the dress panel is slightly larger than the inner box panel, hence the difference in dimensions. Dress panel fitting is shown overleaf.



The completed inner box, from the front, with all holes cut, ready for internal fitout and wiring and the installation of dress panels.

Senator

Speaker Parts List

Timber requirements (per enclosure)

Kaboodle 450mm Wall Cabinet (Bunnings Part No W-51623) (16mm HMR panels)
2 End Panels (Bunnings: Seduction Red part no D65744)*
1 Door (Bunnings Seduction Red part no D65699)*
1 Shelf (becomes angled 'diffuser' panel) 415 x 280mm
1 Side Support (113 x 417mm, 16mm MDF or DAR timber)
* Other colours will have different part numbers

Other components required (per enclosure)

1 10" Woofer (Electric Factory 28/NTR10-2520D) #
1 Compression Driver (Electric Factory 28/CDX1-1730) #
1 Horn (Electric Factory 28/H1-7050) #
1 150mm offcut of 90mm PVC stormwater pipe
1 Terminal Plate (Jaycar PT3012)
1 Handle Pocket (Jaycar HS8012)
4 Legs to suit (Bunnings 100mm chrome "Leggz" Pack of 4)
2 rolls acrylic fibre (acoustic wadding) 700 x 1000mm (Jaycar AX3694)
1 Crossover PCB assembly (see next month)
1 cartridge of neutral-cure silicone sealant

~ 2m heavy-duty figure-8 polarised speaker wire
48 50mm 10g woodscrews (countersunk head)
16 10g 40mm stainless woodscrews
Miscellaneous screws to suit terminal plates, crossover PCBs and hand-holds
(www.elfa.com.au)

side with a jigsaw fitted with a fine-tooth blade.

(d) You will need to cut holes in the cabinet carcase for the loudspeakers etc and you will also need to cut corresponding holes in the front panel for the loudspeakers and the bass reflex port.

e) These holes are best cut with a jigsaw from the "back" side for best results (so that the gloss exterior finish is not likely to be scratched). The same comment applies when you need to cut a side panel slightly shorter to act as the top of the cabinet.

(f) You will need some 16mm MDF or particle board cut to the dimensions given in the relevant diagram parts list to make up the side support panel.

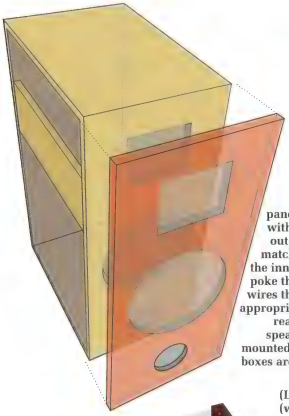
(g) The four adjustable feet supplied with the Kaboodle kit should be left in their packing until the enclosure is finished and the hardware mounted.

(h) The Kaboodle shelf should not be discarded as it is used to make the angled reflector panel inside the enclosure.

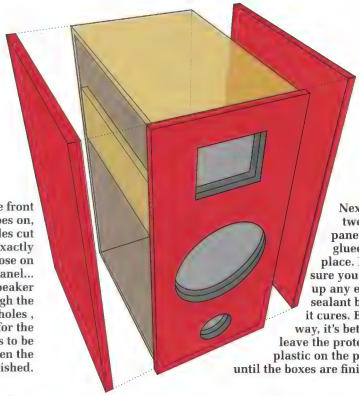
(i) The driver units are mounted using stainless steel screws 10G x 18-25mm, countersunk head. They are the last items fitted.

Next month

We'll conclude the assembly of The Senator speakers with details of the crossover, as well as tying up some loose ends (such as wiring, fitting feet, etc).



The front panel goes on, with holes cut out to exactly match those on the inner panel... poke the speaker wires through the appropriate holes , ready for the speakers to be mounted when the boxes are finished.

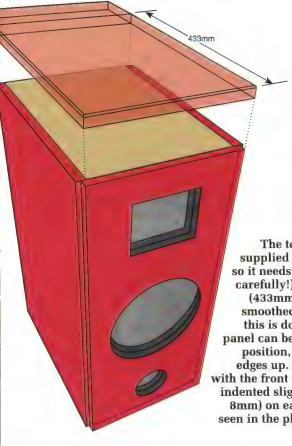


Next, the two side panels are glued into place. Make sure you wipe up any excess sealant before it cures. By the way, it's better to leave the protective plastic on the panels until the boxes are finished.

(Left): the crossover (which we finally mounted on the bottom of the box) is hidden by the rolled-up acoustic wadding in this photo. The front dress panel is also glued in place, ready for the speakers to be connected. We painted the inside (and some of the outside!) of the 90mm PVC pipe to make it less obtrusive. This detail will be covered next month.

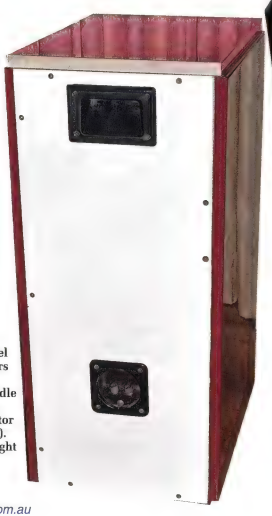
(Right): from the opposite side (looking from rear to front), the completed inner box with the input terminal plate and "pocket" handle fitted, along with the acoustic dampening acrylic material. Note how we've dangled the speaker wires through their holes, ready for mounting.

Prototype boxes shown:
Final versions are not mirror-image and have rectangular tweeter holes.



The top panel as supplied is too long, so it needs to be (very carefully!) cut to size (433mm deep) and smoothed off. When this is done, the top panel can be glued into position, chamfered edges up. It sits flush with the front surface but indented slightly (about 8mm) on each side, as seen in the photo below.

Here's what your finished Senator speaker boxes should look like, immediately before mounting the speakers in the holes. The back and underneath are not covered by dress panels; they're the only ones that aren't. SC



The rear panel of the Senators houses the "pocket" handle (top) and the input connector plate (bottom). This out-of-sight panel is not covered by a dress panel.

Radio, TV & Hobbies April 1939-March 1965

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SPECIAL FEATURE: ElectroneX

electronics design & assembly expo

If you plan on visiting this year's ELECTRONEX 2015 at the Melbourne Park Function Centre, you're going to have to get your skates on – it's on in just a few days' time, September 9 (10am-6pm) and 10 (10am-5pm).

In this special feature, we highlight several of the exhibitors. The exhibition is being held in conjunction with the SMCBA conference and will feature a number of conference seminars, with keynote addresses by several industry leaders.

Organisers of ELECTRONEX expect more than 1000 trade visitors to attend the show over the two days.

ELECTRONEX alternates between Melbourne and Sydney and will not be returning to Melbourne until 2017, so make sure you get along to see this year's show. The expo is open to trade and industry visitors with an interest in the electronics industry and SILICON CHIP readers are invited to attend, free of charge.

At last year's show in Sydney the show was well supported by readers with around 50% of visitors indicating that they regularly read SILICON CHIP magazine.

Readers can register to attend the exhibition in advance at www.electronex.com.au

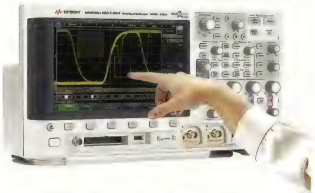
ElectroneX Exhibitor List

(As at August 1 – May be subject to change)

Exhibitor or representative	Stand
ADM Instrument Eng.	B6
Alfatron Pty Ltd	A5
Ampec Technologies	B24
Altronics Distributors	A8
Amphenol*	A8
APM*	C12
ASSCON*	A9
Atten*	A8
Autotronik*	A9
Benbro Electronics	B40
Chemtools*	A8
Congatec Australia	A1
Control Devices Australia	A19
Dataforth*	C12
DBD Innovations*	B40
Dedicated Systems	B33
Deutsch*	A8
Dinkle*	A8
DLPC Pty Ltd*	B26
Duet Electronics	C1
Dymax Corporation*	C36
Electro Harmonix*	A8
Electrolube*	B15
Embedded Logic Solutions	C34
Emona Instruments	A23
Entech Electronics	B25
Erntec Pty Ltd	B12
ESI Technology Ltd*	B6
Europlacer	B27
Fine-Mark Design	C41
Fairmont Marketing	B26
Flexible Circuit Tech	C17
Future Tech Concepts	B18
Gainspan*	A16
GLW*	A9
Glyn Ltd	A16
GPC Electronics	B7
Hakko Australia*	B15
Hakko New Zealand*	B15
Hawker Richardson	A20
Hammond Electronics	A27
Henchman Products *	B28
Hetech	C18
HK Wentworth	B15
IMP Electronics Solutions	C2
Invensense*	A16
Janome Industrial Equip.*	C36
Juki*	A9
Keithley*	C6
Keysight Technologies	A12
Kobot Systems Pty Ltd	B32
Kolb*	A9
Komax WIRE*	A9
Leica Microsystems	C11
Lelon*	A8
LPKF Laser & Electronics*	C34
M2M Connectivity	B16
Machinery Forum (Vic)	C22
Manson*	A8
Marque Magnetics Ltd	A18
Mastercut Technologies	C16
Mathworks	C13
Mean Well Australia*	B6
Mechatronic Systems*	C34
Mektronics	B19
Mentor Graphics Group	B29
Microeo Limited	C35
Micron*	A8
Microsemi*	C12
Mornsun*	B26
Mouser Electronics	B23
National Instruments	C27
Netcomm*	A16
Neutrik*	A8
OKW*	B9
Onboard Solutions	B36
Oritech Pty Ltd	B28
Oupiin*	A8
Ourpcb Australia	C3
Photoetch Industries Ltd	C39
Powertran*	A8
Precision Electronic Tech	B1
Pros kit*	A8
QualiEco Circuits	A17
Radytronic*	A8
Redback Test Services	C23
Reid Indust. Graphic Prods	C14
Rigol Technologies*	A23
Ritec*	A8
Rohde & Schwarz (Aust)	B20
Rolec OKW Aust. NZ.	B9
Salecom*	A8
Scientific Devices Aust	C12
Sensirion*	A16
Silabs*	A16
Sniper Electronics	A7
Stanford Research*	C12
Suba Engineering	A9
Sulzer Mixpac*	C36
Sun Industries	B2
Sunon*	A8
SMCBA	C40
Taiwan Trade Centre Sydney	A4
Tagarno*	A9
TecHome*	C18
Teledyne*	C12
Tekt Industries	B31
Tektronix*	C6
Telit Wireless Solutions*	A16
ThinkRF*	C12
Transmille*	C12
TRIO Test & Management*	A12
UniMeasure*	B6
UVpacific	C36
VGL Allied Connectors	C37
Vicom Australia	C38
ViscoTec*	C36
WDT TooiTech*	A9
Westwick-Farrow Media	A6
What's New in Electronics*	A6
WURTH Elektronic	C26

** Denotes Company/Brand Represented by Exhibitor.*

Touch, Discover and Solve with Keysight's 3000T X-series Oscilloscopes



Keysight Technologies Australia will be exhibiting in ElectroneX Melbourne 2015 at booth A12.

The new Keysight 3000T oscilloscope is the next-generation of the InfiniiVision X-Series. With its zone touch triggering, you can trigger on any signal in just two steps – so you can isolate a signal in seconds.

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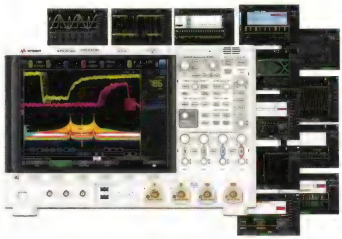
The application software on your oscilloscope improves your ability to debug your system. Therefore, take advantage of this program while it lasts and receive the Ultimate Scope. www.keysight.com/find/Ultimatescope

Call Keysight Technologies Australia on 1800 629 485 – or ask for more details when you visit Keysight on booth A12 at ElectroneX 2015.



Emona at Electronex 2015 — Stand A23

Emona Instruments, a leading supplier of electronic test and measuring instruments is demonstrating a number of new product releases at Electronex 2015.

New products at ELECTRONEX include the MegiQ affordable and compact USB driven Vector Network Analyser. This fully bi-directional two-port VNA allows detailed impedance measurements of antennas, components and circuits, covering 400to 4000MHz, i.e. all popular communication bands for GSM-LTE, GPS, ISM, Wifi, Dect etc. Other new product demonstrations include the Rigol's DSA-875 7.5GHz spectrum analyser and the Rigol DG-5000 350MHz arbitrary function generators.

Emona offers a complete range of test and measuring instruments including oscilloscopes, function generators and counters, data acquisition, multimeters, power supplies, thermal imaging cameras and a range of products to support manufacturers including hipot and production testers and harness and cable testers.

All products are supported by Emona's team of Applications Engineers that provide on-site product demonstrations and our service and calibration department providing full after sales technical and calibration support for our range of equipment. Engineers should also visit Emona's new website at **www.emona.com.au** that offers users a powerful product filter capability making it quick and easy to find the right product for your application.

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MathWorks — ElectroneX Stand C13

Accelerating the pace of engineering and science

With ready-to-use algorithms and hardware connectivity for developing autonomous mobile robotics applications, Robotics System Toolbox provides an interface and complete integration between MATLAB and Simulink, and the Robot Operating System (ROS).

Now, robotics researchers and engineers can work in a single, integrated design environment to design, test, and deploy robotics algorithms on ROS-enabled robots and robot simulators such as Gazebo and V-REP. This creates more time to focus on design explorations and iterations by reducing the manual rework of conversion from MATLAB to ROS.

Algorithms offered within Robotics System Toolbox include map representation, path planning, and path following for differential drive robots. Engineers can now design and prototype motor control, computer vision, and state machine applications in MATLAB or Simulink, and they can integrate them with core algorithms in Robotics System Toolbox. Engineers can also generate a ROS node from a Simulink model and deploy it to a ROS network through the automatic C++ code generation support.

"Robotics System Toolbox brings the algorithm development and system design capabilities of MATLAB and Simulink to the exciting world of Robotics," said Sameer Prabhu, industry marketing director, MathWorks. "Researchers, engineers, and students can now develop a variety of mobile robot applications for use in automotive, aerospace, defense, medical, and industrial automation systems in a fully integrated environment featuring MATLAB and Simulink, and ROS-enabled robots and simulators."

For availability and pricing, see Mathworks at ELECTRONEX Stand C13 or log onto **mathworks.com/products/robotics**

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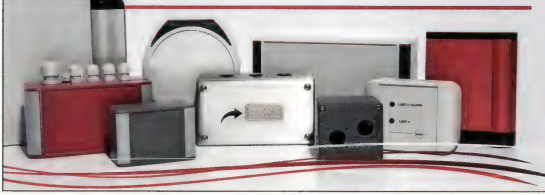

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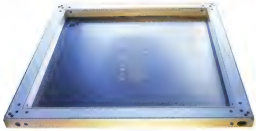

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Benchtop Source Measure Unit with Touch Screen from Keithley

Keithley Instruments, Inc., a world leader in advanced electrical test instruments and systems, will show the first benchtop Source Measure Unit (SMU) instrument with a capacitive touchscreen graphical user interface at ELECTRONEX. The Model 2450 SourceMeter SMU Instrument combines the intuitive touchscreen and icon-based control that novice SMU users can appreciate.

The Model 2450's design, Keithley's latest generation of SMU instruments, offers a fundamentally new way for users to interact with test and measurement instruments. It is based on the company's innovative "Touch, Test, Invent" design philosophy.

This new design philosophy reflects recent market changes, including shrinking product design/development cycles and fewer personnel devoted exclusively to test engineering tasks. At the same time, the profile of the typical instrument user has also evolved. In addition to electrical engineers, it now includes a growing number of non-engineers (such as electrochemists, physicists, materials scientists, etc.) who need fast access to data but sometimes have limited training in electrical measurement.

Additionally, as the previous generation of electrical engineers has retired, their younger replacements have tended to be more software oriented than hardware oriented. To accommodate all of these market and user changes, the Model 2450 incorporates numerous ease-of-use features that ensure a faster "time-to-answer" than competitive solutions, including a context-sensitive help function, "Quickset" modes that speed instrument configuration, and on-screen graphing capabilities that quickly turn raw data into usable results.

If you can't make it to Keithley on Stand C6 at ELECTRONEX 2015, visit www.touchtestinvent.com

Hetech and TecHome combine to offer design-to-manufacture service

Hetech is an established Electronic Design and Manufacturing operating throughout Australia. They have been providing customer specific solutions and concept-to-delivery products for 25 years.

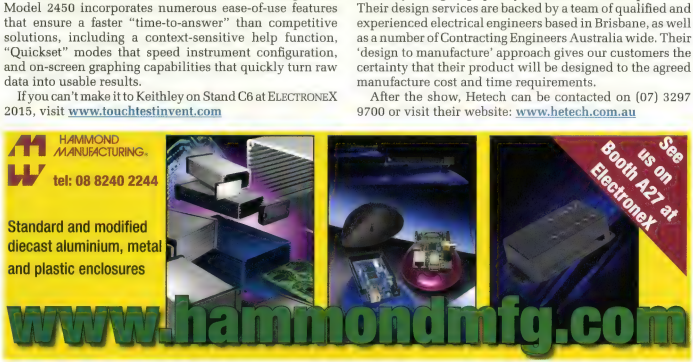
Hetech will be exhibiting their range of manufacturing and design services at stand C18, co-exhibiting with sister company, TecHome, who provide actuator and control products to the manufacturing sector. Visit their stand to experience our electronic and design work first hand and see how they can become your product development and manufacturing partner.

They partner with their customers, walking them through our all-encompassing range of product development services from concept generation, design, testing and volume manufacturing.

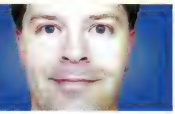
Electronics manufacturing has been the foundation of Hetech for over two decades. Ongoing investment in innovative technology, for example Surface Mount Technology, enables Hetech to offer quality services at the highest international manufacturing standards.

Hetech has also developed a strong reputation for successfully designing quality Australian made products. Their design services are backed by a team of qualified and experienced electrical engineers based in Brisbane, as well as a number of Contracting Engineers Australia wide. Their 'design to manufacture' approach gives our customers the certainty that their product will be designed to the agreed manufacture cost and time requirements.

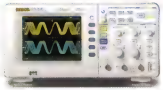
After the show, Hetech can be contacted on (07) 3297 9700 or visit their website: www.hetech.com.au



"Rigol Offer Australia's Best Value Test Instruments"



Oscilloscopes



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- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

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NEW RIGOL DS-1000Z Series

- 50MHz, 70MHz & 100MHz, 4 Ch
- 1GS/s Real Time Sampling
- 12Mpts Standard Memory Depth

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- 9kHz to 1.5GHz, 3.2GHz & 7.5GHz
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RIGOL DP-832

- Triple Output 30V/3A & 5V/3A
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Multimeter

RIGOL DM-3058E

- 5 1/2 Digit
- 9 Functions
- USB & RS232

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EMONA

email testinst@emona.com.au

ELECTRONEX Stand A23

web www.emona.com.au

Automatic Pick & Place

Enriching its prototyping assembly solutions, Embedded Logic Solutions Pty Ltd introduce the Mechatronics P30 desktop Automatic Pick & Place machine with dispensing head.

Capable of placing up to 1200 components per hour with dispensing rate of 1200 dots/hour, the P30 can accommodate up to 40 automatic 8mm feeders along with 40 manual 8mm strips and 2 IC trays while maintaining an A4 size workable PCB area of 200mm x 300mm.

The machine has a placement accuracy of 30µm and qualified for placement of standard and fine pitch components including SOIC, PLCC, BGA, µBGA, CSP, QFN and LEDs targeting the prototyping and low volume production area.

Additional P30 features include: CAN bus Smart Feeder System, vision assisted touch-less component alignment, Automatic Fiducial Recognition, 6 tool automatic nozzle changer, vision inspection of placement and dispensing accuracy and an Internet Remote Service Port.

Highlighting the company's End-to-End prototyping solutions, Embedded Logic Solutions will be showcasing the P30 along the S63 PCB router from LPKF, Mechatronic Systems Reflow ovens and PCB EDA tools from Pulsonix and Easy PC at Electronex 2015 Melbourne Stand C34.

Or visit www.emlogic.com.au

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ElectroneX
Stand A19
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Defence and Australian industry collaborate on counter-improvised explosive devices

Defence and Australian industry partners including Micreo Limited have collaborated to manufacture first-of-a-kind counter improvised explosive device equipment. Australia continues to be on the cutting edge of the development of defence science and technology needed to address the global threat posed by improvised explosive devices.

Micreo was one of a number of industry partners to collaborate with the Capability Acquisition and Sustainment Group, the Defence Science and Technology Group and Defence's Counter-Improvised Explosive Device Task Force to produce this potentially lifesaving equipment.

Under Defence's REDWING program, Australia has developed low cost, robust and lightweight force protection systems. The equipment has particular application for use in austere operating environments by military and police units as it requires minimal operator training and limited logistic support. Two systems have been produced, namely GREENGUM (to equip dismounted forces) and GREYGUM (for fitting to light vehicles).

Through this project, the Australian Government will invest up to $50 million in the Australian defence manufacturing industry, demonstrating Defence's ability to transfer domestically developed counter improvised explosive device technology into jobs for Australians. This project is an example of Australian industry and Defence collaboration, entrepreneurship and innovation to a deliver unique solution that is able to help address a persistent threat in almost every conflict zone.

With defence industry partners supporting an accelerated production schedule, delivery of this vital equipment to Afghanistan commenced in January. The Afghan National Defense and Security Forces are now deploying this equipment in the current fighting season, their first without significant coalition support.

Micreo Limited is an Australian-based independent company founded in 2002 which currently employs 70 people. In the REDWING program, Micreo has applied its technical and management skills to deliver significant quantities of both the GREENGUM and GREYGUM units in a four month period, providing temporary jobs and experience for an additional 40 trainees whilst meeting the quality and delivery targets.

The core business of the company is the design and manufacture of RF and photonic products for Radar and Electronic Warfare avionic systems. To learn more, visit www.micreo.com.

ROLEC OKW Australia New Zealand will be at ELECTRONEX 2015 Stand B9 showcasing the very best designs from their innovative range of aluminium, plastic and stainless steel enclosures, suspension arm systems and accessories.

Highlights from the ROLEC product range will be their extensive range of IP67/IP69K powder coated die-cast enclosures: aluCASE, aluDISC and aluPLUS, all with standard features such as recessed lids for membrane keypads and labels, integral lid retaining straps and clip-on trim covers to hide unsightly lid screws; external mounting brackets are no longer required as the enclosures can be mounted on a wall or machine while still assembled.

OKW will have an extensive range of award winning enclosure designs on display. These include the innovative Synergy enclosures which feature combined aluminium/plastic construction. A range of modern, functional and ergonomic desk top, hand-held, wall mount, instrument, mobile and wearable enclosures will also be featured on the stand

We look forward to meeting you to discuss all your enclosure requirements.

ROLEC OKW Australia New Zealand P/L
Phone: (02) 4722 3388; web: www.rolec-okw.com.au

On display at Electronex 2015: the Graco PR70 Meter, Mix & Dispense Systems

Visit the HK Wentworth/Electrolube stand (B15)

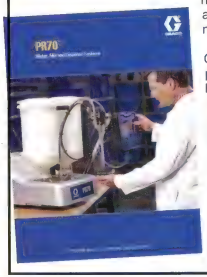
Encapsulating electronics with epoxy, polyurethane and silicone resins has become a growing need for electronics manufacturing over the years. Whether thermal conductivity is required, environmental protection, extremely wide operating temperatures or intrinsically safe applications, encapsulating resins are widely used in Electronics manufacturing globally.

Most encapsulating resins are generally two-part liquid form and require accurate mixed ratios to ensure optimum properties are achieved.

This brings us to the discussion of hand mixing encapsulating resins and the ability to completely automate the dispending process by using automated two-part liquid dispensing machines.

Manual handling of encapsulating resins can become messy, resin waste levels can be high, inaccurate, and inconsistent and heavily rely on the competency of the manual handler when measuring mixed ratios and mixing correctly.

Furthermore, OH&S polices need to be strict and guidelines outlined for manual handling to allow employees to handle these products in a safe and responsible manner.



This brings us to the Graco two-part liquid dispensing machine, offered by Graco Limited and distributed in Australia by HK Wentworth and the Electrolube division.

If you can't get to Electronex 2015 and want to know more about the PR70, call HK Wentworth on (02) 9938 1566 or visit www.hkwentworth.com.au

ELECTROLUBE

THE SOLUTIONS PEOPLE

Electrolube is a leading international manufacturer of high specification, formulated chemical products for a vast array of applications, including those in the electronics, automotive, marine, aerospace, military and telecoms industries. A division of the H. K. Wentworth Group, Electrolube has been providing bespoke solutions and 'off the shelf' products since 1941.

Product categories include Aqueous and Solvent-based Cleaning, Thermal Management, Conformal Coatings, Encapsulation Resins, Contact Lubricants and Maintenance & Service Aids. This wide product range, combined with vast global expertise and established resources, ensures that Electrolube is uniquely positioned to meet and solve customers' needs worldwide, with the highest level of customer support, service and delivery provided.

The company's deep commitment to research and development, quality control and environmental concerns are fundamental to the Electrolube philosophy of providing customer service that's responsive, dedicated and accessible. This is achieved both direct to manufacturers and via a worldwide network of subsidiaries and distributors.

Production materials are delivered in convenient packaging with multi-lingual labeling and Electrolube's international network of field service professionals and specialist distributors are connected directly to Technical Support, providing prompt and efficient assistance.

As a collaborative organization, Electrolube works closely with customers to understand their technical requirements and ensure that fast-changing technological and manufacturing advancements are in turn, matched in performance by evolving solutions.

This also facilitates working in partnership with customers to provide bespoke solutions, tailored to customers' specific demands. Customer support representatives also offer extensive advice on product selection to help customers find the most pertinent solution for their process requirements.

The environmental effects of products used by the market place are of paramount importance to Electrolube, with in-house, expert chemists consistently evaluating new materials to provide safer working conditions for operators and the environment at large. Electrolube has received the ISO 14001 standard from the BSI for its highly efficient Environmental Management System.

Electrolube is headquartered in the UK with international offices located in the USA, China, France, Germany, Australia and India.

The continued global expansion of Electrolube and its innovative range of environmentally friendly products prove that total dedication to customer care and innovation create a winning formula.

Please visit www.electrolube.com for more information.

3D Imaging with HD Image Capture

ElectroneX Stand A20

The new Mantis Elite-Cam HD combines amazing 3D imaging with the power and convenience of HD image capture, producing an unbeatable inspection solution ideal for PCB inspection, rework and reporting. The patented optical viewing head of Mantis Elite-Cam HD provides unrivalled 3D images, as well as significant ergonomic advantages, where fatigue and eye strain associated with working under magnification are eliminated.

As easy to use as a bench magnifier, Mantis unlocks a world of enhanced productivity with its patented Dynascope eyepiece-less head.

Mantis Elite-Cam HD allows freedom of head movement and does not require the user to align the eyes precisely to fixed eyepieces. The benefits are that users can work more comfortably for longer, increasing user comfort and productivity.The extra-long working distances are a considerable advantage where engineers can solder under magnification with the advantage of plenty of room between the lens of the microscope, the PCB and soldering iron.

With superior optics, pads and joints can be easily soldered with optimum clarity and contrast.Mantis Elite-Cam HD has a fully integrated HD camera, so you can inspect, then capture HD images seamlessly, or view and record live video for training purposes. The included software allows easy image mark-up for documentation purposes as well as control of essential camera functions.

Mantis Elite-Cam HD is available with magnifications up to 20x as well as flexible stand options, including a low profile bench stand with integral substage illumination.

See Mantis Elite-Cam HD in action at this year's Electronex – bring in your items for inspection at stand A20.

Hawker Richardson
75-77 Westgate Drive, Altona North, Victoria 3025
Tel: 03 8369 6600 Web: www.hawkerrichardson.com.au

New colour options brighten up Hammond's extruded enclosures

ElectroneX Stand A27

The 1455 family of extruded aluminium instrument cases from Hammond Electronics Pty Ltd consists of 22 sizes from 60 x 45 x 25 mm to 220 x 165 x 52 mm. All sizes are now available in either a red or blue anodised finish in addition to the original clear and black anodised options.

The 1455 is designed to house PCBs mounted horizontally into internal slots in the body of the case or as an enclosure for any small electronic, electrical or pneumatic instrument. All sizes apart from the smallest ones have a removable slide cover on the case body to allow access to the PCB when it is in situ.

The 14 largest sizes are designed to accept a standard 100 x 160mm or 100 x 220mm Eurocard. All sizes of the 1455 are supplied complete with fixings and self-adhesive rubber feet; flange brackets that enable the unit to be mounted directly to a shelf or wall are also available as an optional accessory.

Two types of end panels are available: either a flat aluminium panel, retained to the case body by a separate plastic bezel or an easy-to-machine one-piece moulded black ABS plastic end panels complete with integral bezel.

Hammond Electronics Pty Ltd
11 - 13 Port Road, Queenstown, SA 5014
tel: (08) 8240 2244 www.hammondmfg.com

Rohde & Schwarz: German engineering quality at a an unexpected price

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Electronics Design & Assembly expo
9–10 September Melbourne

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Established more than 80 years ago, Rohde & Schwarz is a leading global supplier in the fields of test and measurement, broadcasting, secure communications, and radiomonitoring and radiolocation. We help you develop the technologies of the future.

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Power supplies

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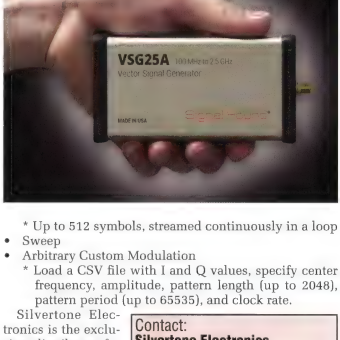
PRODUCT SHOWCASE

Signal Hound VSG25A Vector Signal Generator from Silvertone



The VSG25A 100MHz to 2.5 GHz vector signal generator features a 12-bit I/Q baseband arbitrary waveform generator, which can be clocked at virtually any frequency from 54kHz to 180MHz and includes a 4096×16-bit pattern buffer for built-in or custom modulation.

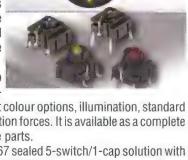
The included software automatically generates:

- CW: 100MHz to 2.5GHz, -40dBm to +10dBm
  Unspecified operation down to 80MHz, or -70dBm to +13dBm
- AM/FM: 30Hz to 40MHz modulation rates, sine, triangle, square, ramp
- Pulse: 6ns to 25ms width, 12ns to 1 second period
- Multi-tone: Up to 1023 tones with optional center notch
  * Use random phase + notch for noise power ratio testing
  * Use parabolic phase for best signal / noise
- PSK: BPSK, DBPSK, QPSK, OQPSK, DQPSK, π/4 DQPSK, 8-PSK, D8PSK, 16-PSK
  * 4k to 45M symbols per second
  * Optional raised cosine, root raised cosine filtering
  * Up to 512 symbols, streamed continuously in a loop
  * Binary symbol editor features 1-click insertion of PN7 /PN9 sequences
- QAM: QAM-16, QAM-64, QAM-256 (same features as PSK)
- ASK / FSK: 4k to 45M symbols per second
  * Optional Gaussian filtering
  * Up to 512 symbols, streamed continuously in a loop
- Sweep
- Arbitrary Custom Modulation
  * Load a CSV file with I and Q values, specify center frequency, amplitude, pattern length (up to 2048), pattern period (up to 65535), and clock rate.

Silvertone Electronics is the exclusive distributor for Signal Hound products in Australia and New Zealand.

Contact:
Silvertone Electronics
1/8 Fitzhardinge St, Wagga Wagga NSW 2650
Tel: (02) 6931 8252
Website: www.silvertone.com.au

"Navigational" switches for menu/ selection apps



The NAVIMEC and panel-sealed CONTROLMEC series provide manufacturers with the ability to design-in a beautiful interface with the performance of the MEC brand.

NAVIMEC, a 5-switch/5-cap solution has many customisation choices including different colour options, illumination, standard and custom legends and actuation forces. It is available as a complete five-piece module or as single parts.

CONTROLMEC offers an IP67 sealed 5-switch/1-cap solution with many of the same options as NAVIMEC, including illumination, laser etched legends/symbols and several colour options. Controlmec also includes a sealing ring, protecting it against dust and liquid ingress.

Both the NAVIMEC and CONTROLMEC solutions can be delivered as loose components, component subassemblies, or integrated into a module with Molex connector for complete plug-and-play functionality.

The switches can be tailored to fit into any application where dependability and performance are critical.

Contact:
Control Devices
Unit 5, 79 Bourke Rd Alexandria NSW 2015
Tel: (02) 9330 1700
Website: www.controldevices.net

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Looking for OMRON ELECTRONIC COMPONENTS ? Try MOUSER ELECTRONICS

Mouser Electronics, Inc. has announced a global distribution agreement with Omron Electronic Components to deliver Omron products to its customers across the globe, making Mouser the only international distributor for their electronic components.

Omron is a leading supplier of a variety of components, including switches, relays, connectors, optoelectronics, and sensors that are used in consumer electronics, computer peripherals, office automation products and telecom applications.

For more information visit www.mouser.com/omron

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Your Total Security Solution

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Better, More Technical

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$34.95

42-Piece Solder Splice Heatshrink Pack
WH-5668
Quickly create sealed soldered joint in one go. Each splice has the right amount of solder to create a secure and well insulated connection when heat is applied. Includes assorted colours and sizes.
See website for full contents.

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Plug-in Environment Sensors
FOR SMARTPHONES
Turn your Smartphone into a pocket environment meter. Choose between four plug-in sensors that measure different environmental conditions. View real time data or set trigger alarms with the free iOS/Android app.

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Mini Network Cable Tester
WITH POE FINDER
XC-5084
Tests UTP/STP/Coaxial/Modular network cables manually or automatically. Detects missing or disordered wiring, and opens or short circuits. Also quickly reads the correct pin configuration of common Ethernet cables. Battery required (use SB-2423).

DOUBLE POINTS FOR REWARDS CARD HOLDERS

DOUBLE POINTS

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1000TVL CMOS Dome Camera
QC-8641
Features supreme HD resolution with 1000 TV Lines. 1/3" 1.2MP image sensor. See pages 2 and 3 or online for more standalone cameras and DVRs.
Available in September

NEW

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$399

Wireless Door Phone
WITH 7" TOUCH SCREEN QC-3624
Perfect for homes or businesses, this doorphone with day/night camera is great for places where a wired unit can't be installed. Records to microSD card (32GB XC-4992 $49.95 sold separately) and allows playback on a TV. Complete with power supplies and mounting hardware.

NEW

$14.95

Battery Operated 16W Soldering Iron TS-1538
Designed to be powered off any 7.2V rechargeable battery commonly used in Electric Remote Controlled Cars. Terminated with a 2 pin nylon plug. 1.5m long lead.
- Suits any Ni-Cd, Ni-MH, Li-ion, Li-Po 7.2V rechargeable battery with compatible connector

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2-In-1 Crimp & Test Tool
TH-1939
An integrated cable stripper and cutter, with detachable cable tester. Network professionals can quickly and easily test Ethernet twisted pair cable for wiring continuity, opens, shorts, and mis-wires. Only 195mm long.
- Suits 10P, 8P, 6P, 4P
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- Includes PoE tester

NEW

FROM $149

Plug & Use LED Headlamp Kits
See more with less glare on the road. These highly efficient LED kits produces extremely bright 2500-3000 lumens of 5500K daylight. Each kit includes a pair of LED lights, controllers and wiring hardware for easy installation. 12/24V.

H7 LOW	SL-3522	**$149**
H4 HIGH + LOW	SL-3524	**$169**

NEW

DOUBLE POINTS

FROM $599

8-Channel Network DVR with Cameras
Records resolution up to 960H capturing all the details day or night. The P2P feature automatically connects with the network for remote viewing. Back-up video recordings to a USB drive (not included) or remotely. Features motion detection and event notification via email. Each kit includes 1TB HDD, software, power supply, mouse and 600TVL cameras.

4 CAMERA KIT	QV-3144	**$599**
8 CAMERA KIT	QV-3145	**$799**

NEW BOARD OF THE MONTH:
YOUR PROJECT CAPABILITIES ARE ENDLESS

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NEW

duinotech Classic (UNO) XC-4410
Introducing our latest range of 100% Arduino compatible boards. Duinotech Classic provides every feature of the Arduino™ UNO and the Freetronics Eleven, now at an even lower price! Top spec ATMega328P Microcontroller with 14 digital I/O. Stackable design and powered from 7-12VDC or USB port.
See page 7 or online for our full range of NEW duinotech boards.

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LED Bargain Pack
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An assortment of over 40 different 3mm, 5mm and 10mm high brightness LEDs.

$9.95

Switches Bargain Pack
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Impressive assortment of over 50 high quality switches, including rocker, tactile, toggle, DIL, push button and micro switches.

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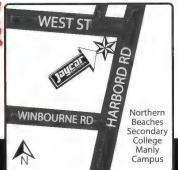
XB-9008
A vast array of over 90 high quality WIMA brand X2 type and other capacitors.

$19.95

Every good hobbyist or technician workshop needs a great collection of spare components and odds & ends. Replenish your own collection with our handy bargain packs. Some contents are worth over three times the price!
Please note: Pack contents may vary to the one shown.



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PRODUCT OF THE MONTH:

UPGRADE TO OUR NEW AHD SURVEILLANCE SOLUTIONS

Jaycar is proud to offer the latest AHD surveillance kits for home and office applications at an affordable price. The AHD (Analogue High Definition) technology allows cameras and DVRs to capture up to 1MP or 720p, the highest Analog TVL available to date. AHD provides better images with higher resolution and lesser noise in comparison to standard analogue (D1) systems & 960H systems. Choose from our AHD DVR camera kits complete with cameras or the standalone cameras and DVRs to suit your surveillance system design. Surveillance just gets better – all using your existing cabling.

Network 4 Channel AHD DVR Kit

WITH 4 X 720P CAMERAS

- 4 x weatherproof 1MP bullet day/night cameras
- Professional AHD DVR with 1TB Hard Drive
- 25fps AHD recording per channel
- Live viewing, recording, playback, backup, network, and copy
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- iOS and Android App available
- Cables, power supplies and mouse included

4 AHD CAMERAS + 4-CH DVR QV-3142 **$699**

4 AHD CAMERAS + 8-CH DVR* QV-3146 **$849**

**Available mid-September.*

NEW! ALSO SAVES FOOTAGE TO YOUR DROPBOX ACCOUNT!

FROM $699 NEW

AHD STANDALONE CAMERAS & DVRS

QC-8637

NEW

$149ea

AHD 720p Cameras

These AHD (Analogue High Definition) day/night cameras deliver crystal clear images and are backward compatible with standard analogue equipment such as DVRs, video splitters/balun, etc. Supplied with power supply and 18m cable.

Specifications:

- Image Sensor: 1MP, 1/4" CMOS
- Pixels: 1280(H) x 720(V) 720p
- Frame Rate: 720p @25fps
- Lens: 3.6mm

AHD OUTDOOR BULLET CAMERA* QC-8637 **$149**

AHD DOME CAMERA* QC-8639 **$149**

**Available mid-September.*

NEW

FROM $399

AHD 720p Network DVR

WITH 1TB HDD

Upgrade your surveillance system to our new high performance AHD technology. Record real time high resolution 720p HD videos over traditional coaxial cable up to 500m. Features:

- H.264 video compression
- 25fps AHD recording per channel
- Live viewing, recording, playback, backup and network
- Continuous/manual/motion detection recording
- iOS and Android App available
- Cables, power supplies and mouse included

4 CHANNEL AHD DVR* QV-3143 **$399**

8 CHANNEL AHD DVR* QV-3147 **$549**

**Available mid-September.*

GREAT ADD-ONS FOR EASY SURVEILLANCE

DOUBLE POINTS

$19.95

Bargain CCTV Video / Power Cables WQ-7279

Make running cables between your camera and your DVR a breeze using this integrated video and power cable. BNC terminated with DC power connectors. 18m long.

DOUBLE POINTS

$19.95

CCD Camera Power Supply MP-3011

500mA regulated switchmode plugpack. Terminates to a 2.1mm DC plug, centre positive. 12VDC.

DOUBLE POINTS

$34.95

AC/DC - DC Converter

MP-3350

Solve your power cabling problem quickly and easily by sending 24VAC down the long run, then converting it to 12VDC. Connection is by screw terminals. 1A max.

17" Colour Surveillance Monitor

QM-3577

High resolution slimline monitor with 4:3 aspect ratio so the camera vision won't appear distorted or stretched, unlike 16:9 monitors. VGA inputs.

Limited stock not available online, purchase in-store only.

DOUBLE POINTS

$199

DOUBLE POINTS

$39.95

CCTV Power Distributor Box

MP-3351

Makes distributing power to multiple CCTV cameras a simple matter. Simply connect a common source up to 30VDC and distribute it to up to 9 slave devices. Screw terminal connection.

- Individually protected PTC output and status LED indicators
- 1-30V AC or DC Input

FREE CCTV STICKER FOR REWARDS CARD HOLDERS* LA-5101 *while stocks last*

LA-5101 VALUED AT $3.95

DOUBLE POINTS

FROM $14.95

Dummy Cameras

Visible deterrents with genuine-looking LEDs to discourage thieves.

LA-5332

DOME + CCTV STICKER LA-5332 **$14.95**

DOME + CCTV SOLAR SIGN LA-5324 **$24.95**

BULLETS + CCTV SOLAR SIGNS (PAIRS) LA-5329 **$54.95**

$14.95ea

Large Security Signs

Prominent and durable acrylic signs for CCTV or dummy surveillance applications. 300mm wide.

CCTV SURVEILLANCE SIGN LA-5114

CCTV WARNING SIGN LA-5115

15% OFF THESE SURVEILLANCE CAMERAS FOR REWARDS CARD HOLDERS

Remote Monitoring from Anywhere, Anytime.

Keep watch over the things that matter to you most from anywhere at any time, offering you peace of mind at the tip of your fingers. Customise your surveillance system with our range of high quality standalone cameras and digital video recorders which allow remote live footage viewing on Smartphones. Easy installation, unbeatable value!

HIGH QUALITY DAY/ NIGHT CAMERAS	QC-8632 BULLET QC-8633 DOME	QC-8634 BULLET QC-8636 DOME	QC-8645 BULLET QC-8643 DOME
Special Features	High quality camera. Power supply & cable included	High quality Sony sensor. Power supply & cable included	Supreme resolution 1600TVL. Mounting hardware included
Sensor	1/3" CMOS	1/3" CCD	1/3" CMOS
Sensor Resolution	752(H) x 582(V)	976(H) x 582(V)	1280(H) x 720(V)
Resolution	600 TV Lines (Max)	700 TV Lines (Max)	1000 TV Lines (Max)
Lens	6mm	6mm	3.6mm
IR Range	10m	12m	20m
Power Consumption	Max 180mA (IR On)	Max 400mA (IR On)	Max 250mA (IR On)
RRP	$99.95 EA	$149 EA	$149 EA

ESSENTIALS FOR YOUR SECURITY SOLUTIONS

REWARDS CARD 15% OFF

D1 4-Channel DVR

QV-3049 **$249**

Supports D1 resolution at 25fps on each channel. Includes 500GB of storage for up to 300 hours of continuous video recording from up to 4 cameras (sold separately).

- Manual, scheduled or movement activation
- USB/HDMI/VGA connection
- Live viewing, iOS and Android App available

REWARDS CARD 15% OFF

960H 8/16-Channel DVRs

Supports 960H high resolution at 25fps on each channel. Includes 1TB of storage for more than 1 month of video recording from the cameras (sold separately).

- Manual, scheduled or movement activation
- USB/HDMI/VGA connection
- Live viewing, iOS and Android App available

8-CHANNEL 960H DVR* QV-8126 **$649**

16-CHANNEL 960H DVR* QV-8128 **$899**

**Available mid-September.*

WIRELESS SURVEILLANCE OFFER

REWARDS CARD OFFER
BUY ALL 4 FOR $390*
SAVE OVER $106

**Please see page 8 for T&Cs.*

Digital Wireless DVR & Camera Kit QC-3676

Simple to install wireless surveillance with infrared camera for day/night recording to microSD card (32GB XC-4992 $49.95). Includes 1 camera and can expand to 4 cameras (sold separately).

GREAT ADD-ONS:

ADDITIONAL CAMERA QC-3677 **$129**

32GB MICROSD CARD XC-4992 **$49.95**

Camera Detector

QC-3506 **$99.95**

Detect covert cameras and listening devices with this handy little unit. It uses 6 pulsing LEDs to reveal the location of a camera by illuminating its lens when you look through the lens viewer from up to 10m away. Earphones supplied for discrete use.

- Built-in wireless RF detector with audible buzzer

REWARDS CARD 15% OFF

Covert Surveillance Cameras $149 EA

High quality 800TVL security cameras for use in covert locations such as shops and businesses. Concealed cables, 12VDC.

Warning: Should not be placed in areas where there is an expectation of privacy. Illegal use of these cameras can lead to criminal prosecution and severe penalties

PIR QC-8652

SMOKE DETECTOR QC-8650

REWARDS CARD 15% OFF

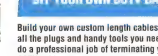
7" TFT LCD Monitor QM-3752

Complete your surveillance kit with this quality widescreen monitor. Features 1140(H) x 234(V) high resolution, NTSC/PAL, multi-source inputs, reverse image function. 12/24VDC.

DIY YOUR OWN CCTV CABLES

Build your own custom length cables, plus all the plugs and handy tools you need to do a professional job of terminating your CCTV cables.

DOUBLE POINTS



CCTV Combo Cable

WB-2017

Combines RG59 coax and 16G power cable. Also sold in 100m roll.

DOUBLE POINTS NEW

Coaxial Connectors

RG-59 CRIMP MALE PLUG PP-0688 **$3.25**

RG-59 TWIST-ON MALE PLUG PP-0678 **$3.95**

BNC FEMALE WITH SPRING TERMINAL PA-3716 **$4.95**

2.1mm DC Connectors

WITH SCREW TERMINALS

PLUG PA-3711

SOCKET PA-3713

DOUBLE POINTS

Handy Tools

Terminate your CCTV cables professionally with these quality rotary cable stripper or ratchet crimp tool.

CABLE STRIPPER TH-1820 **$19.95**

CRIMP TOOL TH-1846 **$39.95**

SECURE AND PROTECT YOUR PROPERTY AND VALUABLES

Jaycar's range of high quality vandal-proof and easy to install wired alarm systems take the guess work out of securing your loved ones and household or business. Easily set up and configure multiple zones which can be monitored and enabled independently for different access levels.

$149

4-Zone Wired Alarm Kit

LA-5475

Includes:

- Control unit & external siren
- 2 x PIRs & 4 x reed switches
- Power supply and mounting hardware

SPARE PIR LA-5476 **$29.95**

FREE 2 X PIR FOR REWARDS CARD HOLDERS* LA-5476

TOTAL VALUE AT $59.90

$439

10-Zone Wired Alarm Kit

LA-5562

Includes:

- Control unit & LCD remote controller
- 4 x PIRs & 2 x reed switches
- External siren
- Power supply, cables and mounting hardware

SPARE PIR LA-5564 **$29.95**

SPARE LCD REMOTE CONTROLLER LA-5563 **$49.95**

FREE 1 X CONTROLLER & 2 X PIR FOR REWARDS CARD HOLDERS* LA-5563 LCD Remote Controller, LA-5564 PIR

TOTAL VALUE AT $109.85

ENERGY EFFICIENT SURVEILLANCE

$39.95 NEW

All-in-One Security Spotlight

SL-3238

Solar rechargeable with PIR for day/night use. Adjustable spotlight head to shine the light where you need it most. Easy to install. Bright 250 lumens.

$149

SAVE $30

Solar Rechargeable LED Floodlight SL-2808 WAS $179

LED light automatically turns on when darkness falls, and activates when the PIR detects motion. Includes 3W solar panel and 3m cable. Very bright 500 lumens.

BUY 2 FOR $15

SAVE $4.90

Water Leakage Alarm

LA-5163 **$9.95**

Detect water leakages before its too late! Ideal for areas prone to flooding or leaks. Built-in magnet for easy mounting to metal surfaces. Batteries required.

BUY 2 FOR $8

SAVE $3.90

Combo Magnet/Reed Switch

LA-5070 **$5.95**

You have both types of contacts on the one unit. Normally open (NO) and normally closed (NC) per pair.

GREAT DEALS ON ALARMS & ACCESSORIES

NOW $26.95

SAVE $8

Standalone Motion Activated Alarm

LA-5217 **WAS $34.95**

Easy to install PIR sensor with wide 120° coverage. Features loud 120dB alarm and delay function. Includes remote.

NOW $24.95

SAVE $10

Pressure Activated Mat Alarm

LA-5218 **WAS $34.95**

Do not miss any visitors (or intruders!) at your door. Switchable chime and alarm modes. Includes loud 120dB siren and strobe. Easy to install and maintain!

Multi-Sensor PIR Detectors

LA-5044

Reliable and effective PIR detectors for added peace of mind. Easy to install, excellent false alarm suppression. The quad unit offers higher levels of detection.

DUAL PIR LA-5044

WAS $29.95 NOW $24.95

SAVE $5

QUAD PIR LA-5046

WAS $34.95 NOW $29.95

SAVE $5

FROM $24.95

SAVE $5

Narrow Electric Door Strikes

LA-5077 **WAS $34.95**

Upgrade your conventional door locks to keyless entry electronic access. Fail-secure mode to keep a door locked shut during power failure for internal security. Suits narrow doors.

NOW $29.95

SAVE $5

ESSENTIALS TO COMPLETE YOUR ALARM SYSTEM

DOUBLE POINTS

$9.95

Indoor Alarm Piezo Screamer

LA-5256

Very popular for indoor use with house alarms as it emits a loud piercing sound making it near impossible to stay inside. Dustproof and waterproof. 100db output.

DOUBLE POINTS

$14.95

Blue Siren/Strobe

LA-5306

Make an emergency situation known instantly with this siren and LED strobe combo. Extremely loud 120dB output, ideal for alarm systems. 12V.

DOUBLE POINTS

$19.95

Alarm Relay Module

LA-5558

Enables you to supply an external power source so as not to overload the power supply and switch high currents to multiple sirens and strobe lights in large alarm installations. 15A rated.

FROM $12.95 SB-2496

DOUBLE POINTS

High Quality SLA Batteries

Long life and maintenance-free. Ideal for standby and emergency applications to keep your alarm systems on the go. *See website for full range.*

6V 1.3AH SB-2495 **$12.95**

6V 4.5AH SB-2496 **$14.95**

12V 1.3AH SB-2480 **$19.95**

12V 4.2AH SB-2484 **$27.95**

ALSO AVAILABLE:

AUTOMATIC SLA BATTERY CHARGER

MB-3527 **$34.95**

HOME AUTOMATION - SECURITY AT YOUR FINGERTIPS

With our new low cost wireless home automation and alarm systems, you can now create a fully automated and secure system without breaking your bank. Control your lighting, heating/cooling, security, etc all through the one system and enjoy the cold winter in your favourite couch.

Basic Infrared 16-Zone Kit

LA-5591

$249 LA-5591

Kit includes mains switch, key fob, wireless main controller, PIR, reed switch and batteries.

UPGRADE PACK 1 INCLUDES:

WIRELESS BELL BOX LA-5579 **$139**

WIRELESS IR CONTROLLER LA-5597 **$99.95**

WIRELESS SWITCH CONTROLLER LA-5595 **$69.95**

REWARDS CARD OFFER

LA-5591 + UPGRADE PACK 1

$399

SAVE OVER $158

Ultimate 10-Zone Kit

WITH SMARTPHONE APP

LA-5568

$599 LA-5568

Kit includes mains switch, lighting controller, key fob, wireless main controller, PIR, reed switch & siren, and batteries.

UPGRADE PACK 2 INCLUDES:

WIRELESS RELAY SWITCH LA-5577 **$149**

WIRELESS SWITCH CONTROLLER LA-5580 **$54.95**

REMOTE CONTROL LA-5573 **$59.95**

NEED HELP ON HOME AUTOMATION OR ALARM SYSTEMS? TALK TO OUR FRIENDLY STAFF IN STORE TO FIND A SUITABLE SOLUTION FOR YOU.

REWARDS CARD OFFER

LA-5568 + UPGRADE PACK 2

$699

SAVE OVER $163

WIRELESS HOME AUTOMATION ACCESSORIES

$49.95

Wireless Mains Light Dimmer Module LA-5596

Remotely controls the intensity of your 240V lamps with incandescent bulbs. It has 8 steps of light dimming, perfect for mood light setting. Up to 100m line of sight. 433MHz.

Suits LA-5591 Home Automation Kit

$74.95

Wireless Solar Doorway Beam LA-5593

Add an entry warning system to doorways, garages, etc. Solar rechargeable so no need to worry about swapping out batteries or connecting up mains wiring. Detects up to 6m away. 433MHz.

Suits LA-5591 Home Automation Kit

$119

Wireless PIR Solar Light Sensor LA-5599

Enhance your security with this automated light triggering kit. Extremely bright LED with adjustable PIR sensor. Solar rechargeable and detects up to 7m away. 433MHz.

Suits LA-5591 Home Automation Kit

$79.95

Doorway Entrance Buzzer LA-5193

Designed for use in commerical applications, workshops etc. to alert you to the entry of customers and visitors. Mains adaptor included. Up to 6m range. Adjustable alarm time & volume.

ALSO AVAILABLE:

WATERPROOF DOORWAY BEAM LA-5179 **$109**

DOOR EXTENSION BUZZER LA-5188 **$34.95**

DOOR COUNTER LA-5197 **$44.95**

$64.95

Wireless Magnetic Reed Switch LA-5584

Compact and energy-efficient switch provides entry protection from windows and doors. Mounting hardware supplied. Up to 100m line of sight. Protocol: 2.4GHz UIS.

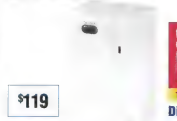
Suits LA-5568 Home Automation Kit

$69.95

Wireless Mains Control Relay LA-5575

Designed to be plugged to a 230VAC source or wired in, it allows wireless control of up to 2 mains devices such as lights, mains switches, appliances, etc. 10A @240V. Protocol: UIS ZigBee® Pro.

Suits LA-5568 Home Automation Kit



$119

Wireless Mains Controller LA-5578

Use this 240VAC plug in mains controller to remotely activate any mains appliances. Turn appliances on and off via the Gateway or remote control devices. Protocol: 2.4GHz UIS. ***Suits LA-5568 Home Automation Kit***

FREE 4 x RFID TAGS FOR REWARDS CARD HOLDERS 2 x 22-8950 Keyfob RFID Tags, 2 x 22-8952 Card RFID Tags

TOTAL VALUE AT $19.80

$129

Digital Keypad

WITH RFID ACCESS LA-5353

Must have for any access control, door monitoring and interlock applications. Great for standalone doors, both inside or outside a building. Durable, waterproof and vandal resistant. Up to 2000 users. 12VDC.

WIRELESS ACCESS CONTROLS

NOW $19.95

SAVE $5

Wireless Doorbell

LA-5029 **WAS $24.95**

Simply plug the receiver into a powerboard or power point. Compact size. 32 melodies. Battery powered button transmits up to 100m.

NOW $59.95

SAVE $15

Wireless Intercom

AI-5500 **WAS $74.95**

Perfect for communicating around your home or office. Built-in monitor function. Mains powered and transmits through house electrical wiring. 2 channels. Sold as a pair

FREE KEYFOB FOR REWARDS CARD HOLDERS SR-2417

LR-8856 $14.95

LR-8858 $19.95

FREE 9V BATTERIES (6 PACK) FOR REWARDS CARD HOLDERS SR-2417

SR-2417 VALUED AT $13.95

FROM $44.95

LR-8855

Remote Control Relay Boards

Add remote control functions with these handy relay boards. Each channel can be set to momentary or latching mode allowing you to customise the setup to suit your application. 40m max transmission range. 12VDC.

2-CHANNEL RELAY BOARD LR-8855 **$44.95**

4-CHANNEL RELAY BOARD LR-8857 **$59.95**

Handheld Remote Controller

LR-8827

Now you can afford more that one remote for garage door, gates, alarms, etc. Operates on 27.145MHz. 9V batteries required.

$64.95

PORTABLE POWER ANYWHERE

We've put together 3 simple bundle offers to give you additional savings off our top selling lines. Each of the packages include everything you need to set up a complete 12V/DC power system. Available in 120W, 180W and 360W packages to suit your power needs.

120W Solar Package ZM-9320

TOTAL VALUE OVER $1127

PACKAGE INCLUDES:

1 X 120W FOLDING SOLAR PANEL ZM-9134 **$499**
1 X 100AH DEEP CYCLE GEL BATTERY SB-1695 **$429**
1 X 1200 LUMENS WATERPROOF FLEXIBLE LED STRIP LIGHT ST-3950 **$99.95**
1 X BATTERY BOX WITH TWO CIG LIGHTER SOCKETS HB-8500 **$99.95**

See our website for more product specifications and warranty info.

$999

SAVE OVER $128

ALSO AVAILABLE:

180W Solar Package ZM-9322

TOTAL VALUE OVER $1492

Package includes 180W folding solar panel, 20A charge controller, 100Ah battery, battery box with power sockets and two flexible LED strip lights.
See our website for information on products included

$1299

SAVE OVER $193

360W Solar Package ZM-9316

TOTAL VALUE OVER $2335

Package includes two 180W folding solar panels, 30A MPPT charge controller, 100Ah battery, battery box with power sockets, two flexible LED strip lights and high current Anderson connectors.
See our website for information on products included.

$1999

SAVE OVER $336

PORTABLE SURVEILLANCE

50% OFF SPARE CAMERA FOR REWARDS CARD HOLDERS QC-3211
Valid with purchase of QC-3217

SAVE OVER $39

$139

Rechargeable Camera and Monitor Kit QC-3217

Truly portable multi-purpose camera kit with exceptional unobstructed range of up to 250m! Suitable for virtually any surveillance application in the car, home or camping. 2.4GHz

SPARE CAMERA
QC-3211 **$79.95**

$159ea

SAVE $20

Wi-Fi HD IP Cameras QC-3844

Easy to setup and stream video with audio across your Wi-Fi network for live viewing during day or night. Mains adaptor supplied. 720TVL@30fps. 1/3" colour CMOS sensor.

720P PAN/TILT QC-3844 **WAS $179**
720P OUTDOOR QC-3846 **WAS $179**

BACKUP, SEARCH & KEEP WATCH

$44.95

DOUBLE POINTS

Siren WITH MICROPHONE LA-5262

Perfect for public adddress. Features multiple selectable siren tones. It also comes with a microphone so doubles as a powerful PA system. 12V.

$79.95

DOUBLE POINTS

8" Parabolic "Spy" Microphone AM-4040

This parabolic reflector with inbuilt microphone magnifies sounds from up to 100 metres away and produces crystal clear digital recordings which are downloadable when you need it. Fabulous product!

- Includes 8x image magnifier/monocular and high quality headphones
- Requires 9V battery

HB-6389

REWARDS CARD **15% OFF**

ABS Instrument Case WITH PURGE VALVES

Ideal to protect your sensitive devices during transit. Sealed with a rubber gasket, and includes pluck foam for your gear. Six sizes available from 173 to 530mm wide.

173 X 125 X 50 MM	HB-6389 **$24.95**
210 X 135 X 90 MM	HB-6388 **$34.95**
330 X 280 X 120 MM	HB-6381 **$59.95**
430 X 380 X 154 MM	HB-6383 **$89.95**
515 X 415 X 200 MM	HB-6385 **$119**
530 X 355 X 225 MM	HB-6387 **$175**

FROM **$119**

SAVE UP TO $40

MP-5205

Uninterruptible Power Supplies WITH USB

Don't get caught with lost data from power failure. Protect your computer systems with these smart UPS. Features easy to read LCDs which show battery and load value percentage and input/output voltages.

650VA/390W UPS 25min Backup Time*
MP-5205 **WAS $139 NOW $119 SAVE $20**
1500VA/900W UPS 94min Backup Time*
MP-5207 **WAS $319 NOW $279 SAVE $40**
** Based on small load. See website for details.*

$79.95

DOUBLE POINTS

Rechargeable HID Spotlight ST-3379

35W HID bulb produces huge 1700 lumens of bright light. Fully featured with inbuilt rechargeable battery, 240V and 12V charger, dual-LED map light and swing away stand.

AC-1705

FROM **$34.95**

HDMI Switchers

Ideal for monitoring surveillance at a single point from multiple HDMI sources. Supports 3D video. Auto or manual switching, powered by the HDMI device. Remote control supplied.

3 INPUT AC-1705 **$34.95**
5 INPUT AC-1706 **$69.95**

KEEP YOUR WORK AREA SAFE

REWARDS CARD **15% OFF**

Gas Leakage Detector

QP-2299 **$39.95**

Gas leaks can be incredibly dangerous. This unit with visual/audible warning detects butane, propane, acetylene and methane (natural gas) gases. Batteries required.

2-In-1 Network Cable Tester and Digital Multimeter

XC-5078 **$79.95**

This autoranging DMM allows you to easily check cable integrity or measure AC & DC voltage, etc without carrying two separate devices. LAN terminator, loopback cable and DMM leads included.

REWARDS CARD **15% OFF**

REWARDS CARD **15% OFF**

Inspection Camera WITH 3.5" DETACHABLE WIRELESS LCD

QC-8712 **$279**

View and record video and pictures in confined and dark locations. The head and flexible boom are IP67-rated for use in harsh environments. 1m flexible boom. 2.4GHz.

- Hook, mirror, magnet & 2GB microSD card included

EXTENSION SHAFT 2M QC-8702 **$79.95**

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE & BE REWARDED WITH A $25 REWARDS CASH CARD ONCE YOU REACH 500 POINTS!
Conditions apply. See website for T&Cs

REGISTER ONLINE TODAY BY VISITING:
www.jaycar.com.au/rewards

INTRODUCING DUINOTECH! 100% ARDUINO COMPATIBLE

	NANO XC-4414	LITE XC-4430	MEGA XC-4420
Microcontroller	ATmega328P	ATMega32u4	ATMega2560
Clock	16MHz		
Flash Memory	32kB	32kB	265kB
SRAM	2kB	2.5kB	8kB
Digital I/O Pins	14	7	54
Analog Pins	6	12	16
Size (mm)	46(L)x18(W)x18(H)	75(W) X 53(L) X 13(H)	108(W) X 53(L) X 15(H)
RRP	$29.95	$29.95	$49.95

If you have already immersed yourself into the exciting world of Arduino, or wanting to, then you'll love our extensive new range of Arduino compatible products we've affectionately named, **duinotech**. Here's just a small selection of the duinotech products on offer at Jaycar to build whatever creation you desire, from controlling lights or motors, to complete robotics applications. To learn more, download simple projects to get you started.

Visit our dedicated website deca.jaycar.net

duinotech

NEW

FROM $29.95

XC-4414

MINI PC + ARDUINO = PCDUINO! SPECIAL DEALS FOR REWARDS CARD HOLDERS

Want the ability to use a standard hard drive for bulk storage? Jaycar's pcDuino boards combines the features of a computer with a onboard SATA port and Arduino compatible headers. Preloaded with Ubuntu Linux for ease of use.

See website for details.

FREE 1.8M USB TO MICRO USB LEAD FOR REWARDS CARD HOLDERS* WC-7724

While stocks last. Limit 1 per customer. WC-4352

WC-7724 VALUED AT $9.95

$89.95

PcDuino V3.0 Nano
XC-4352

REWARDS CARD OFFER

BUNDLE DEAL!

$239*

SAVE OVER $28

*Please see page 8 for T&Cs.

REWARDS BUNDLE:

BUNDLE INCLUDES:

PCDUINO V3.0 WITH WI-FI XC-4350 **$119**

7" LCD TOUCH SCREEN MONITOR XC-4356 **$139**

USB A TO USB MICRO-B LEAD 1.8M WC-7724 **$9.95**

BUILD YOUR OWN DUINOTECH LASER SECURITY SYSTEM

Light Dependent Resistors
Cadmium Sulphide (CdS) light dependent resistor cells suitable for all your light-sensitive projects.

TWO MODELS AVAILABLE:

2.8kΩ TO 8.4kΩ RD-3485

48kΩ TO 140kΩ RD-3480

$3.25 ea

$3.50

Stackable Header Set HM-3207
The perfect accessory to the ProtoShields and vero type boards when connecting to your Arduino compatible project. 2 x 8 pin and 2 x 6 pin included.

$14.95

Laser Pointer ST-3102
High quality metal construction. Batteries included.

Warning: Do not stare into beam

FROM $12.95

PB-8814

Solderless Breadboards
Ideal construction base for Arduino and electronic projects. With clearly labelled rows and columns and adhesive back for mounting.

300 TERMINAL HOLES PB-8832 **$12.95**

600 TERMINAL HOLES PB-8814 **$19.95**

ALSO AVAILABLE: 70-PIECE MIXED JUMPER WIRES PB-8850 **$13.50**

$16.95

Resistor Pack 300-Pieces
RR-0680

This assorted pack contains 5 of virtually each value from 10KΩ to 1MΩ.

See website for full contents.

$29.95

LED Pack 100-Pieces ZD-1694
This assorted pack contains 3mm and 5mm LEDs of mixed colours. Even includes 10 x 5mm mounting hardware FREE!

See website for full contents.

ESSENTIALS FOR ARDUINO PROJECTS

DOUBLE POINTS

$4.95

ProtoShield Basic XC-4214
Provides plenty of space to add parts to suit any project, keeping everything neat and self-contained. Includes dedicated space to fit a power LED and supply decoupling capacitor.

DOUBLE POINTS

$12.95

ATmega328P Microcontroller
ZZ-8726

An Atmel AVR microcontroller with pre-installed Arduino Uno bootloader to build customised Arduino compatible projects. Includes 16MHz crystal oscillator.

DOUBLE POINTS

$27.95

ICSP Programmer XC-4237
Program new applications into a wide range of microcontrollers using this ICSP programmer with a USB interface. Compatible with a wide range of microcontrollers, including all Arduino boards. Compatible with Windows, Mac, and Linux.

NEW

DOUBLE POINTS

$99.95

1.3" Round LCD Module XC-4284
This innovative circular display is ideal for graphical gauges, needle-meters and robotics projects. Easy to program and interface to your projects. Includes an Arduino adaptor shield, a 5-pin header, jumper leads and a 4GB microSD card.

- Colours: 65K
- Resolution: 220 x 220 (Round)

DOUBLE POINTS

$8.95

Shift Register Expansion Module XC-4240
Drive up to 8 devices using just 3 pins on your microcontroller. They can also be daisy-chained together to drive 16 channels or more.

DOUBLE POINTS

$12.95

Sound & Buzzer Module XC-4232
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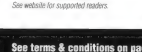

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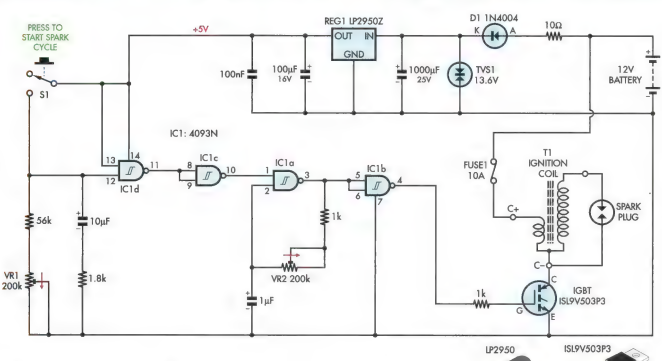
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Benchtop ignitor for oxy-acetylene welding

This simple unit is designed to generate a spark suitable for ignition of an oxy-acetylene flame. It utilises a standard automotive ignition coil and spark plug as can readily be found in a junk box or obtained from a car wreckers.

The coil is driven using an IGBT (insulated gate bipolar transistor) in a manner similar to that used in the recently described Jacobs Ladder (SILICON CHIP, February 2013). It is powered by a 12V sealed lead-acid battery and can be housed in a metal box (resistant to the inevitable flames and sparks), enabling it to be moved around to where the job is.

The IGBT is driven by a 4093 quad 2-input NAND Schmitt trigger IC. IC1d is gated on by microswitch S1 and the adjustable ON time is set by the components connected to pin 12.

Peter Shooter is this month's winner of a $150 gift voucher from Hare & Forbes

IC1d's output at pin 11 is inverted by gate IC1c and fed to pin 1 of IC1a. When pin 1 is high, IC1a functions as an oscillator with its frequency set by trimpot VR2, in conjunction with the other components connected between pins 3 & 6. IC1a's pulse train output is inverted and buffered by IC1b and used to drive the gate of the IGBT via a 1kΩ resistor.

Positive pulses to the gate of the IGBT cause it to turn on and current flows through the primary winding of the ignition coil. When the pulse ceases, the IGBT turns off abruptly and the collapse of the magnetic field in the primary results in a high-voltage output from the secondary and a spark across the plug gap.

. . . continued on page 63

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Efficient linear multi-voltage regulator

This circuit was devised to increase the amount of current available when deriving several different voltages from a single transformer secondary while keeping dissipation reasonable. The obvious method is to use switchmode regulators but this circuit uses simple linear regulators instead and so avoids the drawback of any RF interference.

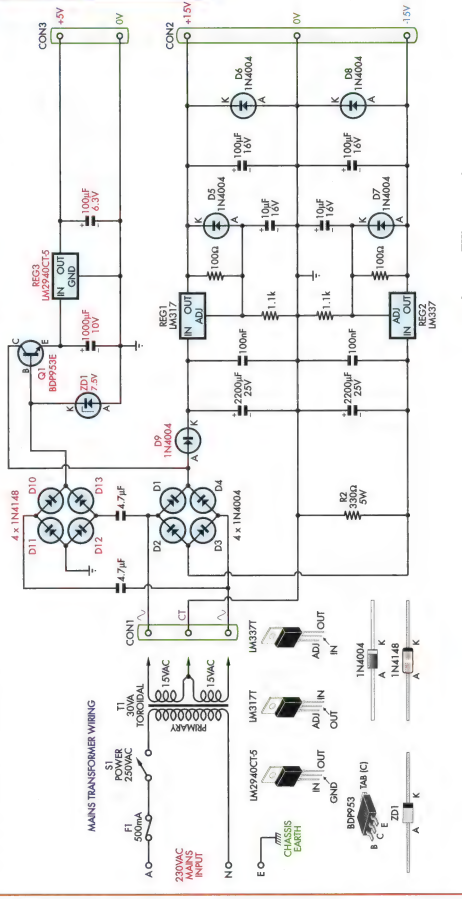
While it's best to use a transformer with multiple sets of secondaries to do this, a suitable transformer may not be available. This circuit gives an alternative approach with only slightly greater complexity.

This circuit is based on the power supply used for the Studio Series Preamplifier and the Stereo DAC, as shown on page 21 of the September 2009 issue of SILICON CHIP. Basically, the output from the centre-tapped 30VAC transformer secondary was rectified and filtered using two 2200µF capacitors and then regulated to ±15V. The positive filter capacitor was also tapped to supply a 7805 regulator to provide a +5V rail.

A 100Ω 5W dropper resistor in the September 2009 circuit reduces dissipation in the 5V regulator and that limits the available current to about 120mA, with 1.7W dissipated in the resistor and 0.3W in the regulator. But what if you wanted to get 500mA from the 5V output and so reduced the resistor to 22Ω? You would then have 5.6W dissipation in the resistor and 2.1W in the regulator – a total of nearly 8W and too much for the components to handle!

This circuit provides the same amount of current from the 5V output with just 3.7W of dissipation, split between an NPN power transistor (3.1W) and the regulator (0.6W). The transistor would probably need a heatsink but the regulator would not. The components added or changed from the original circuit are labelled in red.

It works because the transistor only switches on to charge up the 1000µF reservoir capacitor at those times when the rectified AC voltage is slightly higher than the reservoir



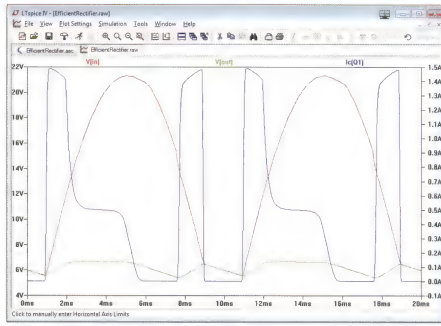
capacitor voltage. The regulator's input voltage varies between about 5.5V and 7V. Since the differential voltage across the regulator is low, its dissipation is low.

The only downside, apart from the extra components, is that the current pulses drawn from the transformer have a higher amplitude because they are quite brief.

It works as follows: the 4.7µF capacitors couple the transformer secondary AC voltages to a second bridge rectifier consisting of signal diodes. The result is a phase-shifted, rectified waveform that peaks near the zero crossing points. This current flows through D10 and D13 to turn on Q1 early and late in each half-cycle. It's prevented from conducting until the incoming voltage exceeds its emitter voltage by the main rectifier.

The main rectifier is isolated from REG1's input filter capacitors by an added diode, D9. This prevents these capacitors from affecting Q1's operation but it will reduce REG1's input by 0.7V or so. If this is a problem, D9 can be left out and Q1 can be supplied from CON1 by a separate two-diode rectifier (eg, two 1N4004s from CON1).

ZD1 prevents Q1 from charging REG3's input capacitor up beyond 7V. This limits current flow when the incoming voltage is at its peak level and thus reduces overall dissipation. Note that REG3's input capacitor is larger than in the original design (1000µF compared to 47µF) but can have a much lower voltage rating thanks to ZD1.



Also, REG3 has been changed to a very low dropout type but a standard 7805 could be used if ZD1 were increased to 8.2V and REG3's input capacitor increased in size to 2200µF. The overall dissipation increases to just over 4W, which is still about half that of the original design.

The above screen grab shows the output of an LTSPICE simulation of this circuit for one full mains cycle. Q1's collector voltage is shown in red, its emitter in green and the current through Q1 in blue.

The 4.7µF capacitors need to be non-polar types so SMD ceramics would probably be the best choice. If customising this circuit to suit other transformer voltages, output voltages and currents etc it would be best to simulate it in order to determine the optimal zener diode and capacitor values as these values can affect dissipation quite substantially.

Nicholas Vinen,
Silicon Chip.

Benchtop ignitor: continued from page 61

Trimpot VR2 is adjusted to deliver the "meatiest" spark, while VR1 is adjusted to allow sufficient time for the operator to light a steady flame. Around 5s was found to be sufficient.

S1 can be any momentary contact microswitch activated by using a metal lever arm so the switch itself is out of way of the flame. The lever can be a steel strip mounted on top of the unit's metal box using a hinge. A rod from the lever into the box then activates the microswitch. A tap on the lever with the nozzle of the oxy-acetylene torch activates the spark sequence.

Current drain when off is negligible and the unit could be left on for the duration of the work and only turned off at the end of the day. A standard sealed lead-acid battery charger would suffice to charge the battery.

IC1 is powered from the 5V output of an LP2950Z low-dropout voltage regulator (REG1). This device has a very low quiescent current to enable a long battery life. Diode D1 protects against reverse polarity connection of the battery. TVS1 is a transient voltage suppressor and, in conjunction with a 10Ω current-limiting resistor, protects the voltage regulator and IC1 from transients from the coil's operation. The 1000µF capacitor provides filtering for the regulator's input.

As in the Silicon Chip Jacobs Ladder project, the electronics is supplied by a separate wire from the battery's positive terminal.

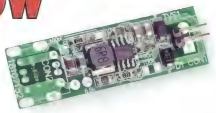
One of the advantages of the unit is that initiating the spark is hands-free, making for a safer workplace, and the operator is not tied to a trolley-mounted igniter, as is the case for a spark-plug driven by a foot-operated magneto or piezo device.

One user remarked that they now turn off the gas instead of leaving the flame burning while they rearrange the work, as re-igniting is so quick and easy, thus saving gas.

Peter Shooter,
Narrogin, WA.

Editor's note: Jaycar have an extended lever microswitch (Cat. SM-1039) that may be well be suited as the lever actuated switch. The 51mm lever can be bent to protrude out of the circuit enclosure. SC

Revised USB Charger Regulator With Low Battery Cut-Out



This revised version of the tiny USB charger module presented in the July 2105 issue now has extra circuitry to prevent any USB device such as a permanently connected dash-camera from discharging the car's battery below 12.15V. We've boosted the continuous output current from 2.5A to 3A and as well as being installed in a motor vehicle, it could be built as a portable USB device charger or for many other purposes.

By Nicholas Vinen

WE'VE HAD a good response to our article in the July 2015 issue on installing USB charging points in a car. One of the benefits of that approach is that the USB sockets are powered even when the vehicle ignition is off, allowing phones and similar devices to be left charging while the car is parked.

That brings up the risk of draining the vehicle battery if those devices are left plugged in long-term, which was discussed in the July article. Basically, the stated solution was to avoid connecting anything permanently if it draws a lot of current from the USB socket on a continuous basis.

One reader asked why we didn't simply incorporate a low-battery cut-out in the circuit to address this. The simple answer is that we were trying to minimise both the complexity of the design and the cost of building the unit. Had the switchmode regulator IC used in that project incorporated a programmable under-voltage lock-out feature (as some do), we would have used it but unfortunately the RT-8299A, despite its other good points, does not.

The RT8299A does have an enable input (pin 6) but this is designed to be driven with a logic signal and it has a low and ill-defined threshold voltage; thus we can't use a resistive divider to set any kind of accurate threshold. An external voltage reference and comparator are therefore required.

Features & Specifications

Maximum sustained input voltage: 15V
Low battery cut-out: 12.15V
Battery cut-in voltage: 12.86V
High efficiency: typically >90%, 0.5-2A
Output voltage range: 0.8-15V, typically 5V (must be at least 2V below input)
Output current: up to 3A
Quiescent current: approximately 1mA
Current with low battery cut-out engaged: typically <10µA
Output ripple and noise: ~5mV RMS @ 1.2A
Load regulation: ~150mV/A, 0-250mA; ~75mV/A, 250-3000mA
Line regulation: <1mV/V
Transient response: output stabilises within ~20µs for a ±1.2A load step
Other features: transient voltage suppression, no heatsinking necessary, soft start, output short circuit protection, output over-current protection, overheating protection

Circuit description

The revised circuit is shown in Fig.1. The top part is basically identical to the original USB charger circuit shown on page 37 of the July 2015 issue, with one small change we'll get to later. The added section below is derived from the Battery Lifesaver circuit shown on page 66 of the September 2013 issue.

The incoming 12V supply connects to linear low-dropout regulator REG2 which provides both the power supply and an accurate reference voltage to micropower comparator IC1. REG2 has

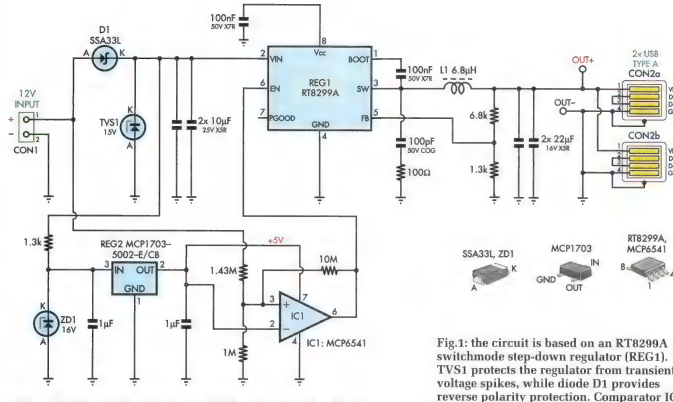


Fig.1: the circuit is based on an RT8299A switchmode step-down regulator (REG1). TVS1 protects the regulator from transient voltage spikes, while diode D1 provides reverse polarity protection. Comparator IC1 shuts down REG1 if the battery voltage falls below 12.15V.

MINI 12V USB POWER SUPPLY MK2

an output voltage tolerance of ±0.4%. The battery voltage is divided by two resistors, 1.43MΩ and 1MΩ.

These values are chosen so that the voltage at the non-inverting input (pin 3) of IC1 drops below the 5V reference at pin 2 once the supply voltage drops below 12.15V. The 10MΩ resistor provides about 0.75V hysteresis, so that if the unit switches off due to a low vehicle battery voltage, it won't switch back on until the battery rises above 12.86V, ie, the next time the engine is started and the battery starts to charge.

So the output of IC1 is high when the battery voltage is sufficiently high and low otherwise. This output goes to the enable pin (pin 6) of REG1 to shut the regulator down when the battery voltage is low. The 100kΩ pull-up resistor originally provided for the EN pin is no longer needed although we've left the pads on the PCB. This allows the original circuit to also be built on this PCB, in which case REG2, IC1 and their associated components are simply omitted.

Added protection

ZD1 and its associated 1.3kΩ resistor are not shown on the photo of the prototype. They were added to the final version to better protect REG2 against supply spikes which are common in vehicles. This is necessary because while TVS1 clamps REG1's supply below its 24V maximum, this is too high for REG2 to handle, with its maximum rating of 18V.

Since ZD1 has a breakdown voltage of 16V, it will not conduct with normal automotive battery voltages (12-15V) but will protect REG2 during the worst spikes. Its leakage current at normal operating voltages is negligible.

When the EN pin of REG1 is pulled low and its output is shut down, it draws less than 3µA. REG2 consumes around 2µA and IC1 around 0.7µA. There's a further 5µA through the battery sense resistive divider for a total of around 10µA. This is well below the self-discharge current of a car battery and a tiny fraction of the load a typical modern vehicle puts on its battery with the ignition switched off.

Note that 1.43MΩ seems like an odd value for a resistor but it is in the E96 series and is easy enough to get. Failing that, you can parallel 5.1MΩ and 2MΩ resistors (both E24 values). Paralleling SMD resistors is easily done since they can be soldered on top of one another.

Step-down regulator

In the July 2015 issue, we explained in detail how switchmode regulator REG1 works. In brief, the voltage at pin 3 (SW) toggles between 0V and the incoming supply voltage (ie, that at pin 2, V_{IN}). When pin 3 is high, current flows through inductor L1 into the output filter capacitors and the load, charging up L1's magnetic field. When pin 3 is driven low, this magnetic field begins to collapse and as as result, current continues to flow into the load but this time it's pulled from ground via pin 4.

The duty cycle of the square wave output at pin 3 is controlled so that the average voltage at the load is very close to 5V. This is determined by sampling the feedback voltage at pin 5 (FB), which comes from a 6.8kΩ/1.3kΩ resistive divider across the output. When the output voltage is 5V, the feedback voltage is 0.8V and this matches REG1's internal reference. If the feedback voltage is too low, REG1 increases the duty cycle and if it's too high, the duty cycle is reduced.

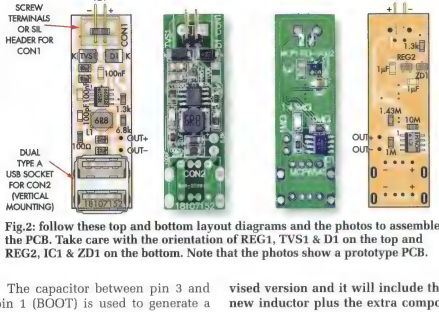


Fig.2: follow these top and bottom layout diagrams and the photos to assemble the PCB. Take care with the orientation of REG1, TVS1 & D1 on the top and REG2, IC1 & ZD1 on the bottom. Note that the photos show a prototype PCB.

The capacitor between pin 3 and pin 1 (BOOT) is used to generate a voltage of around 10V (the output voltage plus 5V) which REG1 uses to drive the gate of its internal Mosfet in order to pull pin 3 high. The series capacitor and resistor from pin 3 to ground form a snubber to reduce the rate of voltage change at this pin, cutting down on EMI.

Increased output current

The literature provided for REG1 suggests a filter inductor value of around 2.2µH. Choosing switchmode inductor values can be quite tricky as there are trade-offs. The advantage of low values such as the 2.2µH suggested is that since they require fewer turns of wire, the wire can be shorter and thicker, thus lowering resistive losses. They can also be physically smaller both due to less wire and a smaller core.

However, lower inductance does mean more output ripple voltage, while changing the inductor value changes the time constants in the switchmode feedback loop and can affect stability and transient response.

The 10µH inductor specified for the original version of this circuit has a continuous current rating of around 2.5A. This time, we tried a similarly-sized 6.8µH inductor with a 3A continuous current rating and a saturation current of 3.9A. Thus we can now obtain the full 3A output specified for REG1 while the ripple level is still very low.

Along with the PCB, we've been supplying a kit of parts for the USB charger project that includes all the SMDs. We'll do the same for this revised version and it will include the new inductor plus the extra components for the low-battery cut-out.

Changing the voltage thresholds

The 12.15V threshold will suit most lead-acid, AGM or SLA/gel cell batteries and should leave sufficient charge to start a motor. However, it's possible some constructors will want to change this, eg, if powering the unit with a Li-ion, LiPo or LiFePO4 battery instead. The easiest way to do this is to replace the 1.43MΩ resistor with a different value – if necessary, by paralleling two standard values.

For a desired cut-out threshold V_{co}, calculate the required value R_{div} in ohms as:

$$\mathbf{R_{div} = (V_{co} - 5V) \times 200{,}000}$$

and pick the nearest value available.

For example, for a 12.5V threshold, use a 1.5MΩ resistor. Calculate the threshold from the chosen resistor value as:

$$\mathbf{V_{co} = (R_{div} \div 200{,}000) + 5V}$$

The cut-in threshold V_{ci} is then:

$$\mathbf{V_{ci} = (R_{div} \div 181{,}818) + 5V}$$

If you need to lower this (ie, reduce hysteresis), increase the value of the 10MΩ resistor; 15MΩ, 22MΩ and 33MΩ SMD resistors are available. Alternatively, to increase hysteresis, lower the value of the 10MΩ resistor. The hysteresis voltage V_h for a feedback resistor R_{fb} is calculated as:

$$\mathbf{V_h = (V_{co} - 5V) \times 1{,}000{,}000 \div R_{fb}}$$

For the value specified, this gives 0.715V. If you need a particular cut-in voltage, calculate the resistor value thus:

$$\mathbf{R_{fb} = (V_{co} - 5V) \div (V_{ci} - V_{co}) \times 1{,}000{,}000}$$

Once again, you will have to pick the closest value you can actually get.

Construction

Fig.2 shows the new component overlay diagrams. The top side is virtually identical to that shown in the July issue; all the extra parts have been added to the bottom. The revised PCB is coded 18107152 and measures 16 x 51mm. It's easiest to fit all the components to the top side of the board first.

Start by fitting REG1. While an SOIC-8 package is generally easy to solder, this one has a thermal pad on the underside which is also supposed to be soldered to the board. To do this properly, you need to use a hot-air rework station. These are available from eBay sellers for around $50 (eg, search for "Atten 858d").

If you have one of these, simply apply some solder paste to each pad, place the IC on top, check its orientation carefully (pin 1 to upper left) and then heat the IC and its leads until the solder reflows. Be sure to continue heating it long enough for the solder on the thermal pad to melt also; you can usually see fumes from the flux escaping under the IC.

While we recommend this method and it's how we built this prototype, it is possible to solder the chip by hand. To do this, first place a small amount of non-conductive (silicone-based) heatsink paste on the central pad and clean the residue off the other pads. Then tin one of the eight remaining pads, carefully place the IC in position and reheat that pad while pressing down gently on the IC until its lead contacts the PCB.

Once it's in place, check the alignment, then solder the remaining seven pins and add some solder to that first pin to refresh the joint. Any solder bridges between pins can then be easily cleaned up using solder wick.

Note that it's best to avoid moving the IC by much during soldering, so that the heatsink paste is not spread around. Also, don't clean the board using any solvents as these are likely to wash the paste away. We used the hand-soldering method successfully when building the original version shown in our July issue.

One of the most common problems with soldering an IC like this is that it's possible to get solder on a pin without it actually flowing onto the corresponding pad. As a result, it's best to check all eight leads under a magnifying lamp to

make sure the solder fillets have properly formed.

With REG1 in place, inductor L1 is next. This is a little tricky due to its high thermal inertia. There are various methods but the simplest is to treat it like a large chip component. This involves adding a fair bit of solder to one of the pads, enough that it's visibly built up, then heating this solder while sliding L1 into place along the surface of the PCB. It's easiest to do this while holding it with angled tweezers.

As soon as L1 hits the solder, some of it will cool and solidify. You will have to hold the iron in place while L1 heats up and the solder will then re-melt. Once that happens, you can finish sliding L1 across into the correct position between the two pads. You can then flow solder onto the opposite pad.

Note that it's best to do this immediately before L1 cools down. Note also that it will take a little while to apply enough heat to form a good joint.

You will then need to go back and add some more solder and heat to the initial pad, until you get a similarly good fillet on that side; much of the flux will have boiled off during the initial soldering process.

Alternatively, use solder paste and a hot air wand although you will probably need to hold the inductor in place using steel tweezers or the hot air may blow it out of position.

The rest of the components are easier as they are substantially smaller but you can use the same basic idea of adding solder to one pad and then sliding the part into place. The only remaining polarised components are D1 and TVS1; in each case the cathode (striped) side goes towards the nearest edge of the PCB.

Don't get any of the different value capacitors, resistors or diodes mixed up. The resistors will have printed value codes on the top but the other components are likely to be unmarked so you will have to remove them from their packaging one at a time and immediately solder them to the PCB.

Bottom side components

Now you'll need to flip the board over but it won't sit straight due to the components sticking up, especially L1. To solve this, get two heavy objects of the same thickness (eg, timber off-cuts) and space them apart on your bench so that each end of the board can rest on one or the other, with the components hanging down in the gap in between.

Now solder IC1 in place. This is similar to REG1 but doesn't have a thermal pad so you can simply tin one pad, slide it into place while heating that pad, then solder the rest of the pins. Be sure that its pin 1 dot is orientated as shown in Fig.2 and clean up any solder bridges between pins using solder wick and a small amount of flux paste.

Next fit REG2 and ZD1, which are both in SOT-23 packages; don't get them mixed up. It's then just a matter of installing the remaining passives, ie, four SMD resistors and two 1µF ceramic capacitors where shown.

Parts List

1 double-sided PCB, code 18107152, 16 x 51mm
1 6.8µH 3A RMS (3.9A saturation) 6x6mm SMD inductor (L1) (Digi-Key ASPI-6045S-6R8M-TCT-ND, element14 2309891)
1 2-way mini terminal block or pin header (CON1) (optional)
1 dual stacked vertical type-A USB socket, through-hole mounting (CON2) (element14 1841169, Digi-Key ED2984-ND) OR
2 vertical or horizontal type-A USB sockets, through-hole mounting (CON2) (element14 1696534/1654064, Digi-Key UE27AC54100-ND/ UE27AE54100-ND)
1 50mm length of 20mm-diameter heatshrink tubing

Semiconductors
1 RT8299AZSP 3A switchmode step-down regulator IC (REG1) (element14 2392669, Digi-Key 1028-1295-1-ND)
1 MCP1703AT-5002-/CB or MCP1703T-5002-/CB 5V LDO regulator (REG2) (element14 1439519, Digi-Key MCP1703AT-5002E/CBCT-ND)
1 MCP6541-(I/E)/SN micropower comparator (IC1) (element14 1557429, Digi-Key MCP6541-E/SN-ND)
1 3A 30V Schottky diode, DO-214AC (D1) (element14 1843685, Digi-Key SK33A-TPCT-ND)
1 SMAJ15A SMD 15V 400W TVS or equivalent (TVS1) (element14 1886343, Digi-Key SMAJ15ALFCT-ND)
1 BZX84B16 16V 0.25W zener diode (ZD1) (element14 2463473, Digi-Key BZX84B16-FDICT-ND)

Capacitors (all SMD 3216/1206*)
2 22µF 16V X5R/X7R
2 10µF 25V X5R/X7R
2 1µF 50V X7R
2 100nF 50V X7R
1 100pF 50V C0G/NP0

Resistors (all SMD 3216/1206*, 1%, 0.25W)
1 10MΩ
1 1.43MΩ (element14 2139709, Digi-Key RHM1.43MCJCT-ND)
1 1MΩ 2 1.3kΩ
1 6.8kΩ 1 100Ω
* 2012/0805-size parts are also suitable

Connectors

The PCB has provision for a pin header or terminal block as the power input, or you can simply solder wires to the two pads – if in doubt of the polarity, check Fig.2.

For the outputs, there is space for one or two on-board USB sockets, either a vertical or horizontal type-A USB socket, or a vertical dual type-A USB socket. However, as explained in the July issue, many constructors will prefer to run wires from the OUT+ and OUT- pads to one or more surface-mounting USB sockets, depending on the exact application.

There were also detailed instructions in the July 2015 issue on how to install the unit in the overhead binnacle in a typical modern motor vehicle. We also explained back then that, should you wish to use the PCB as a general-purpose 3A step-down regulator, you could change the 6.8kΩ feedback resistor to obtain any output voltage from 0.8V up to about 10V.

Should you wish to do this, the new resistor value is simply calculated as:

$$R = (V_{out} \div 0.8 - 1) \times 1.3k\Omega$$

If you plug 5V into this formula you will see that the result is very close to the 6.8kΩ value specified.

Finally, check that the unit works, ie, gives a 5V output for a 13-15V input, then encapsulate it in heatshrink tubing to protect it and prevent short circuits. SC

SERVICEMAN'S LOG

One tricky job & one disgusting job

Dave Thompson*

Fixing the flip-out viewing screen on a Sony Handycam is not for the faint-hearted but patience, Google, lots of photos during disassembly and YouTube helped get the job done. Unfortunately, I wasn't so lucky when our cat sabotaged our digital kitchen scales.

A SERVICEMAN, no matter what area he specialises in, often gets to work on interesting or out-of-the-ordinary jobs. This usually happens when a friend knows that we "fix things" and asks us to have a look at something for them. But it doesn't have to come from someone else; just recently I took on a couple of repairs that popped up in our own household and while they were very different, both involved out-of-the-ordinary jobs.

The first eventuated when I went to use our trusty Sony Handycam video camera. This model is quite a few years old now (in fact, it must be pushing at least nine years) and has worked quite well. It was one of the first hard-drive models where the images and movies are stored on a miniature hard disk instead of on tape or, as in the model we previously owned, written in real time to a mini DVD.

At the time, the hard drive system was a revolution in camera design and although only 20GB in size (a minnow against today's whopper drives), it was massive by the standards of the day and could hold a gazillion photos and more hours of high-quality video than we were ever likely to shoot.

Like most Handycams, it has a flip-out LCD "viewfinder" and this also rotates to enable framing and viewing when taking "selfies", something pretty much unheard of all those years ago but a vital feature for today's self-obsessed smartphone users. Not only is it a viewing screen, it is also a touch screen where one accesses all the controls and settings for functions inside the camera.

In operation, this model camera has the typical record, start/stop buttons, manual zooming and other controls all arrayed at one's fingertips. However, the vast majority of the settings are controlled by tapping through the various menus displayed on the flip-out LCD. And this little screen has proven to be a big headache repair-wise.

I have previously written about a screen-scrolling problem with this device some years ago. At the time, I thought that I'd cured it by disassembling the screen covers and fiddling around with a Mylar connector strap I found inside. After cleaning and re-terminating it, the scrolling had stopped and I'd considered it fixed.

Just recently though, I dug the camera out of the drawer with the intention of recording some workshop videos for a new YouTube channel I am working on. After dusting off the camera and charging the battery, I fired it up for my coming screen debut. And much to my annoyance, when I flipped the screen out, it started scrolling again, just like it had done before except that it was now scrolling much faster and was all but unusable.

This meant that there was no way I could adjust any of the settings because the touch-screen function was inoperable. It also meant that there was nothing for it but to repair the camera but I knew from past experience that these devices are literally packed to the gunnels with delicate electronics and fragile connectors, some so small that only a good set of tweezers can manipulate them. And while I've disassembled many older-style video cameras in order to scavenge parts (eg, to use

Items Covered This Month

- Sony Handycam video camera
- Digital kitchen scales
- Luxman L580 stereo amplifier
- Electric brake controller

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the viewfinder in home-made night-vision goggles), it's a different story when you have to put one back together again and get it working properly!

So I needed some guidance and the only possible resource that could help me in the first instance was Google. I couldn't find an exact match for a service manual but I did find several YouTube videos which showed how to disassemble similar cameras, including one that was a complete walk-through for changing the LCD connector strap! It seems that many Sony Handycams eventually develop this fault – enough anyway for someone to make a "how to" video detailing the strap's replacement. And although the camera was a different model, I hoped that it would be close enough for my needs.

Like many servicemen, disassembling things has never been a problem for me. In fact, I seem to have a natural ability to see what needs to be removed in order to get to where I need to go. However, as anyone who has disassembled a Handycam can tell you, all bets are off when dealing with one of these puppies.

Talk about complicated! Of course, they probably aren't all that complicated for people used to working on them but they really make the most of available space and there are many layers to remove before getting anywhere close to revealing all the connections relating to the LCD. The connections I'd previously cleaned and re-seated were simply the ends that I could see. Unfortunately, several other elements were buried deep within the body of the camera and I literally would have had to strip it right down in order to access everything.

Before starting this new job, I clicked through a link on the YouTube video to a vendor who supplied the replacement strap I was going to need. This strap coils around the complicated hinge assembly and apparently it fails over time. And because it is non-repairable, replacement is the only option.

No worries, at least it was available. But then I discovered how much the vendor, an American-based outfit, wanted for what is essentially a strip of plastic with a couple of connectors printed onto it! I was staggered at the cost and quickly concluded that there had to be another (cheaper) option.

And so, armed with the part number (always handy when searching for spares), I hit my second favourite resource, aliexpress.com. A quick search of the part number revealed several vendors selling these straps at a much more realistic cost and it just goes to show that it pays to shop around (there are lots of rogues out there).

After a brief search, I found one that offered free shipping and ordered two straps for less than NZ$20. That meant that I'd have a spare just in case I mucked one up which, judging by the video, was quite likely. That's because the strap comes in a form that looks completely unlike the finished article. During installation, it must be folded, origami-style, and taped together into exactly the right shape before being threaded in three dimensions around the hinge assembly.

~I FOUND YOUTUBE VIDEOS WHICH SHOWED HOW TO DIS-ASSEMBLE SIMILAR CAMERAS...

It's something I'm not very good at and it looked like an operation that had a high potential for failure. So a spare strap was an excellent idea!

Having ordered the strap, I then spent some time methodically breaking the camera down. I also took lots of photos at every step along the way, just in case I couldn't remember how to re-assemble it later on. This isn't as silly as it sounds; I'm no longer 20-reckless-years old and since it'd be at least a week before the strap arrived (and with other jobs in between eroding my memory), it's a good idea to use every trick available to help with the reassembly of such devices.

There is certainly no shame in documenting every step of a complex job. Running into problems with my own camera would be bad enough but not

being able to reassemble a client's device would be downright embarrassing – and reputation-destroying to boot.

The new straps duly arrived 10 days later and to my surprise, there were not two but five straps in the bag! That really took the pressure off when it came to folding and installing it as I could now muck up more than two and still have spares. As it turned out, I only needed one; the video, like most walkthroughs, left out a few the critical procedures but I muddled on and, using the photos I'd taken earlier, managed to fold and loop the strap through the hinge and to reassemble it all correctly.

One thing the walk-through I followed didn't show (and which wasn't mentioned in any of the other videos) was a tiny switch that's included in our camera. This switch is mounted inside the hinge and flips the image when the screen is rotated to the front, otherwise the image would be upside down and back-to-front. I found this switch (with its own smaller strap) when I was removing the old strap and took photos of it in-situ. And that really helped me when I was putting the screen assembly back together.

This is the new connector before it's folded to go around the hinge assembly. The YouTube video and the photos I'd taken helped me figure it out.

Without the photos I'd taken, and the YouTube video, I reckon I'd have had real problems reassembling this section. As it was, it all went back together quite well and, what's more, I now have four spare straps in case it fails again (or I get another similar camera to work on)!

Reassembling the rest of the camera was basically the reverse of pulling it apart. The main thing to remember was to re-attach all the connectors and install any other bits as necessary before the next layer was installed. Fortunately, Sony's engineers had decided to use the same-sized screws in most locations in this camera. There is nothing more annoying (Apple, are you listening?) than having a different-sized screw for every part that's attached to the device.

In fact, an iPhone uses something like 13 different-sized screws to hold its component parts together and there are even "screw maps" which you can buy or download to show you where each screw goes. But no such dramas here; some screws are different in the Sony Handycam but their positions are obvious.

Even so, this was one of the trickiest repairs I have done in a long time. And I could have made a real pig's ear out of it if I hadn't taken lots of photos when pulling it apart, so that I knew how it all went back together again.

So did the new strap fix the problem? You bet – my old Sony Handycam is now as good as new again.

The cat did it

My next domestic job was relatively simple but decidedly more unpleasant. We have two cats at home and one is now quite old. As such, he is starting to exhibit the classic signs of feline old age, such as toileting in strange places.

Each weekend, my wife and I clean the house so that it's tidy and liveable for the coming week. Obviously, I'd rather be out in the workshop building something but in the interests of domestic harmony, one has to do one's duty.

Recently, while clearing the kitchen bench to give it a good wash down, we found a lake of cat wee underneath our set of digital kitchen scales. It was as disgusting as it sounds and resulted in more than a few harsh words in the direction of the obvious offender.

We thoroughly cleaned and disinfected the bench-top but the scales were a different matter. They sit on low-profile plastic feet and, as a result, they had suffered an infusion of this foul-smelling liquid from said cat. And so, because it is a very good set and well-worth saving, I bundled it off to the workshop in an effort to see what could be done.

Fortunately, I had previously invested in a box of nitrile work gloves. These are basically a type of rubber glove that motor mechanics use when working on engines. They are a lot tougher than normal latex gloves and are ideal for jobs like this.

Once gloved up, and with plenty of tissues and old rags on hand, I set about pulling the scales apart. This involved first removing a couple of PK screws and the battery holder. I then attempted to separate the base from the top half of the scales but while the plastic clips holding everything came away easily, there was obviously something still holding the base in place.

By the look of it, the platen that the scale's bowl sits on needed to come off in order to gain access to some screws underneath. Typically, it didn't want to budge, so some gentle persuasion was necessary until it popped free, breaking three of the four retaining clips in the process. It didn't matter; I could deal with that later.

There were three more screws holding things together and once removed,

the two "halves" could be separated. I then removed the sensor assembly, a remarkably heavy-duty piece of kit for small kitchen scales, then the associated wiring which unplugged from the first of three circuit boards.

These boards, including the display board, were held in with smaller screws on one side and plastic clips on the other. Once undone, the boards came away easily and I could immediately see that they'd were covered with you-know-what. I then took all the plastic bits to the laundry sink and thoroughly washed them in hot-soapy water.

While they were drying, I returned to the circuit boards and sopped up any excess liquid as best I could with tissues. I then cleaned the boards using a damp rag, pushing it along with a flat-bladed screwdriver.

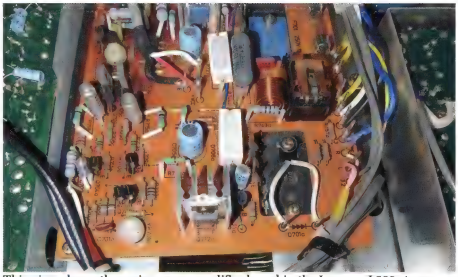
However, despite going over them several times, they still reeked of cat's wee. What's more, there had been a lot of intrusion under the rubber push-button pads for the scale's controls.

I removed these rubber pads and cleaned up with isopropyl alcohol, taking great care to keep this fluid clear of any electronic parts. Unfortunately, after carefully drying and reassembling everything, I found that the LCD readout was fragmented and unreadable. Deflated, I put it all aside and, at the time of writing, plan to let it dry for a few days before having another go at it.

Realistically though, given the corrosive nature of the liquid involved, the scales have probably been given the kiss of death. But it still hurts to go to all that trouble and not get a result.

Luxman L580 stereo amplifier

They sure knew how to make stereo amplifiers back in the 1980s and the Luxman L580 was no exception. This luxury, high-end amplifier was packed with features but it came with a simple design flaw as G. H. of Dandenong North, Victoria recently found out. Here's what happened . . .



This view shows the main power amplifier board in the Luxman L580 stereo amplifier. It has a power output of around 100W per channel

Just recently, a friend of mine said that he had a Luxman stereo amplifier that had stopped working and asked if I would like to have it. What particularly interested me about it at the time was its moving coil preamp and I thought if nothing else was salvageable, I may at least be able to use this.

I really didn't know anything else about the unit until I went to his house to pick it up. To my amazement, it was a high-end 100W per channel L580 amplifier from the 1980s. A quick online search indicated that this is a fine unit and that it would be well worth repairing if that was at all possible. It also intrigued me because after years of being involved in building valve hifi amplifiers, this would be an interesting challenge.

My friend said that it worked fine until one day it just went dead. That was quite a long time ago and he didn't recall if there were any other symptoms leading up to that. When it had failed, it was simply wrapped in a blanket and stored in his garage.

My first impression was of the weight of this beast. Luxman sure didn't skimp on the transformer, heatsinks or any other part of the construction – well, apart from the solder that is, as I was to later discover. I soon found that the full service and alignment manual was available on the net and so I downloaded it. It was then time to take a look inside it.

The layout consisted of nine circuit boards plus a number of hefty wire looms which joined it all together via various connectors, solder joints and, to my surprise, wire wrap connections (I haven't seen those for a long time). The accompanying photograph shows the main power amplifier board.

After determining that all the fuses

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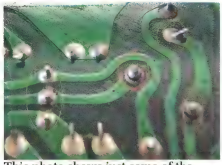

This photo shows just some of the faulty solder joints on the power amplifier board used in the Luxman L580. The solder joint inside the red circle had lifted clear of its PCB pad, while those inside the yellow circles were in various stages of failure.

were intact and that the main filter capacitors weren't leaky, I plugged it in and powered it up. Much to my delight, it didn't catch fire and all the obvious voltages (supply rails, etc) checked OK. What I did discover was that the overload protection relay didn't engage but on the surface everything else looked fine.

As it has preamp out sockets, my next step was to connect these to a separate power amplifier. This indicated that all the preamp functions worked perfectly and that all the pots operated smoothly and quietly.

It was now time to discover if there were any major faults in the power amplifier stages. To do this, I carefully removed the cover from the speaker protection relay, connected a couple of old test speakers via 22Ω resistors (just to be sure) and operated the relay manually. I was immediately greeted with stereo music, much to my delight, but the relay would not stay engaged so the protection circuit was sensing a problem.

A quick voltage check across the speaker terminals showed that 3V DC was present on the lefthand channel, so that explained the relay's behaviour.

A close visual inspection of the power amplifier board revealed some signs of heat stress around the driver transistors. As a result, I began touching various components to test the temperatures (after making sure no high voltages were present) and to my surprise, the speaker relay suddenly clicked in. A check of the speaker outputs now showed a couple of millivolts on both sides.

Surely it couldn't be as simple as a dry joint? I prodded around this stage a bit more and the relay suddenly dropped out again, with 3V again present on the lefthand channel's speaker output terminals. It was time to face the inevitable; I needed to remove the main PCB.

Unfortunately, this board had the majority of the wire-wrap connections and almost no slack in the wire looms, so this was not going to be an easy task. What's more, the main power transistors (large NEC devices) were rigidly soldered to wire-wrap terminals. It was going to be a mechanical nightmare, both to get out and to put back together.

Initially, I took many close-up photos and made detailed drawings which indicated the colour of each wire and where it went. I then got to work and after a couple of hours, I had the board out and was able to take a close look at it. While I was doing this, I noticed one of the driver transistors had actually come loose and was freely rocking from side to side.

When I looked at the underside of the board, the story become clear. It wasn't so much dry joints that were causing the problems but rather mechanical failure of the solder joints. The root cause of this was probably a combination of heat, expansion of the PCB material and minimal solder.

An accompanying photo shows some examples. The solder joint inside the red circle has broken completely free and there were quite a few others like this on the PCB. Similarly, the joints indicated in yellow are in various stages of failure.

Just to be sure, I re-soldered every joint on the power amplifier board as I certainly didn't want to have to remove it again. It was then a matter of going through the time-consuming process of reinstalling the board in the chassis. Unfortunately, it wasn't possible to temporarily hook it up so that I could test it. There was no other option but to reinstall it and see if it worked.

This procedure took another two hours, during which I made careful reference to the photos and drawings I'd made. I couldn't wire-wrap again, so I simply soldered all the leads to the wire-wrap terminals. As a precaution, I did check to see if the output transistors were available in case they needed replacing. It turned out that they were available but they are very expensive, meaning that it would be best to avoid any wiring errors that could destroy them.

When it was all done, I held my breath and turned it on. Much to my relief, the speaker relay clicked in after a few seconds and some quick checks revealed only a few millivolts across each of the speaker outputs.

Having put so much effort into getting this Luxman amplifier going, it was time to see how it performed. I connected it to my Tannoy monitor speakers and fed in signals from both analog and digital sources. To my delight, it really proved to be a nice amplifier. And with a genuine 100W RMS/channel output, it really packs a punch. What's more, the sound is clean and it well and truly matches my more modern transistor amplifiers.

In retrospect, it's easy to understand how the fault occurred. The amplifier runs hot and the PCB material used expands more with temperature than modern PCB material. This combined with the minimal amounts of solder used meant that the joints inevitably fractured over time.

Electric brake-controller

An electric brake-controller is a necessity when towing caravans above a certain weight. G. H. of Littlehampton, SA has a brother-in-law who recently fitted one himself and finished up with a hot foot for his troubles. It happened like this . . .

My brother-in-law Danny recently purchased a new Isuzu MU-X SUV (4 x 4) to tow his newly-acquired cara-

Servicing Stories Wanted

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Please be sure to include your full name and address details.

van. And as part of the deal, he had the dealer fit the tow-bar and socket but not an electric brake-controller.

After visiting various retail outlets and comparing available units on the internet, he eventually opted for an Australian-made unit. It arrived three days later and he was anxious to install it, so he sought my advice.

The first thing that caught my eye was the colour coding of the wiring. There were only four wires: (1) black for the battery positive connection; (2) white for battery negative; (3) red for the brake-light switch connection; and (4) blue which connected to the trailer plug to power the caravan's brakes.

Care has to be taken with the brake-light switch connection (red). That's because many brake-light switches now have four wires, two of which connect to the CPU to cancel out things like cruise-control etc. Of the other two, one is positive and is switched to the other connection to power the brake lights. This lead has to have the fuse for the brake controller fitted to it. We also added an extra fuse of our own in the black positive lead for safety.

It would have made much more sense if the brake-controller's manufacturer had used a red lead for positive, black for negative, white as the positive signal from the brake switch and blue to power the brakes. So why didn't they? It's a mystery to me!

Unfortunately, the red wire out of the unit wasn't long enough to reach its intended destination. What's more, Danny didn't have any red hook-up wire so he added a short length of wiring from stock that he did have and that was blue. Oh, the confusion!

Acting on my advice, Danny made up a wiring harness with all the necessary leads so he would only have to route it once. And he did a very neat job of this, I must say.

The brake controller was subsequently installed under the dash and the various wires trimmed to length and soldered to ensure reliable connections. The leads were then cable-tied and it all looked very professional.

I might add that I was absent during this later work and Danny was very proud of the job he'd done. But it hadn't yet been tested and his moment of truth had finally arrived.

Danny made sure that everything was off in the vehicle and then reconnected the negative battery terminal (he had disconnected this before starting work). He then quickly put his head under the dash to make sure everything was OK and it was at that moment that he felt a simultaneous hot and cold sweat run down his face. What had he just done to his lovely new vehicle? Something was getting hot . . . very hot in fact and it smelt like burning rubber. What on earth had he done wrong?

He quickly got out from under the dash and stood up so that he could rush to the battery to disconnect it. And then aaaaaghhhh . . . he realised he was standing in his thongs on the still hot soldering iron!

By the way, the brake controller worked a treat. SC

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- **LIDAR-Lite** - Laser ranging modules at an affordable price for developers and hobbyists.
- **Virtins Technologies DSO** - Up to 80MHz dual input plus digital trace and signal generator.
- **Bitscope Logic Probes** - 100MHz bandwidth mixed signal scope and waveform generator.
- Firetail and Firetail Diamond UAV autopilot systems.

Manufacturer of the Flamingo 25kg fixed-wing UAV. Payload integration services available.

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ALTRONICS
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Build It Yourself Electronics Centre
Issue: September 2015

It's time to upgrade!

Micron® Curie Heat Professional Soldering Station

The time to upgrade is now! Finally an affordable and high performance curie heat soldering station. It features adjustable temperature, zero-voltage ESD safe spike protection, temperature lock out & energy save mode. **Optional T 2081 SMD tweezers & holder also available $209.**

What is curie heat technology?

Curie heat is fast replacing traditional ceramic heating elements. The tip is composed of a special magnetic alloy which heats up fast and maintains consistent temperature preventing damage to boards and parts whilst ensuring reliable solder joins between component and pad. It's a massive leap in soldering technology for the pro or enthusiast.

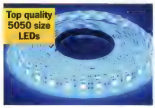
Universal Aircon Remote

Lost your aircon remote? Or has your enthusiastic toddler destroyed the old one? This replacement works with hundreds of aircons, both old and new!

NEW!
$24.95
A 1014

Bargain 1080p Dashboard Camera

With G-sensor which automatically saves videos when heavy braking occurs. In-built 2.7" TFT screen. HDMI out. Loop video recording. Includes windscreen mount, car power adaptor and USB lead. Requires Micro SD card (32GB $39.95).



New Blue LED Strip Lights

Sold in 5m rolls in either indoor or IP65 rated for outdoor use. Great for adding atmosphere to your entertaining area. 12V DC input via 2.1mm DC jack.

NEW!
$44.95
X 3209A Indoor

NEW!
$54.95
X 3205A Outdoor

Keep your eyes on the road with a HUD

Suitable for any vehicle with an OBDII port, this handy head up display (HUD) allows you to keep your eyes on the road at all times. It shows current speed, RPM, fuel consumption, common warning lights and more!

Universal Car Phone Mount With NFC

Universal design suits just about any phone or phablet up to 80mm wide. NFC function launches your favourite app when your phone is in the mount.

NEW!
$29.95
D 2200
360° adjustable!

C 5283

$75
SAVE $34

Mini Cube Speakers: Small on size, big on sound!

Subtle appearance with swivel mount drivers. Ideal for the kitchen, study or bedroom. 15W 8Ω. Size: 130Hx65Wx75Dmm.

Bluetooth FM Transmitter & Handsfree Kit

SAVE 19%
$32

Make hands-free calls in the car and listen to your favourite tunes on your smartphone via FM transmission to your car radio. Fitted with 2.1A USB charge outlet.

Watch live TV on your phone with no data charges!

Watch TV whilst out and about. Simply plugs into your micro USB charging port and provides the ability to pause live TV, timeshift and PVR program recording. Works with FetTV app on the Google Play store. **Works with Android USB 'On-The-Go' equipped phones.**

NEW!
$19.95
T 2264

Digital Luggage Scales

A handy travel accessory to make sure you don't get stung with excess luggage charges. 40kg max.

Zmodo® 720p Wi-Fi IP Camera

With IR LEDs for night recording. High quality 720P resolution. Easy plug and play set up. Remote viewing via Android or iOS app. On board SD card slot for recording.

SAVE $20
BARGAIN!
$99
S 9009

Connect USB devices up to 100m away

Great for connecting USB drives and devices between rooms. Requires power at receiver end (plugpack included). 100m max over Cat5e/6.

USB Microscope Camera

High resolution 9 megapixel sensor. Great for electronic inspection, educational or visual aid (reads fine print with ease!)

- 200x zoom • LED light
- Still shot and video capture function
- Focuses down to 5cm! • Add on a microscope stand for $55 (X 4310)

$145
SAVE $34
X 4304

Stock up on popular parts...

Space & time saver!

From $7.95/rl

NEW RANGE!

Handyman Hookup Reels

Red & black hook up cable in 10m or 30m lengths, 7.5, 10 and 15A rated. Ideal for automotive & marine use. All are tinned conductors to reduce corrosion.

$9.95 ea

NEW RANGE!

Handyman Heatshrink Reels

Short lengths of red or black heatshrink (2:1 ratio) on a handy reel. Keeps your workbench neat and tidy.

Size / Length	Black	Red
3mm / 8m	W 0712	W 0722
5mm / 5m	W 0713	W 0723
6mm / 5m	W 0714	W 0724
10mm / 5m	W 0715	W 0725
13mm / 3m	W 0716	W 0726

NEW!

$34

T 2982 50mm

NEW!

$6.95

T 2980 5mm

Conductive Copper Tape

A multitude of electronic uses - create low-profile component traces, RF-shielding, antennas etc. 0.07mm thick. 15m length.

Buy 3 for $72 SAVE 19%

Buy 3 for $36 SAVE 22%

Lead Free	Leaded
T 1075: 0.5mm	T 1090: 0.5mm
T 1078: 0.8mm	T 1100: 0.8mm
T 1080: 1.0mm	T 1110: 1.0mm
T 1084: 1.5mm	T 1122: 1.6mm

Quality Resin Core Solder

Top grade for easy reliable soldering.

NEW!

$19.50

18650 Lithium Batteries

S 4732 With Tags
S 4736 Standard

3.7V 2600mAh: As used in high power LED flashlights.

NEW!

$29.95

S 2710 Momentary

Plunger Limit Switch

10A @ 250V AC, IP65 rated for industrial use. Plunger type, suitable for panel mounting.

Z 6222A

SAVE 15%

$14

Funduino Pro Mini 328

A 5V 16MHz clone board of the Arduino pro mini. Ideal for building into a compact embedded design.

Kinsten® Blank PCB

Fibreglass positive resist blank single sided PCB. Developer to suit H 0798 $2.95/pk.

Single Sided	Part	ONLY
114x165mm	H 0772	$7.30
150x300mm	H 0774	$16.60

F 130

NEW

F 260

Mini Motor Bulk Buy

High torque F260 or low torque F130 hobby motors.

Type	Model	5 for
F130 1.5V	J 0022	$12
F130 3V	J 0024	$10
F260 4.5V	J 0026	$15

SAVE 22%

$11

Z 6327

4 Channel 10A Relay Board

Ideal for integration with Arduino & Pi projects. 5V DC coil. Opto-isolated inputs.

Q 0584

SAVE 17%

$33

0-100A Ammeter & Shunt

Includes matched shunt for easy connection. 50W x 26H x 23.5Dmm.

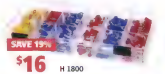
Q 0585

SAVE 24%

$19

8-30V DC Volt Panel Meter

Red 3 digit display. 0.1V resolution. 50W x 26H x 23.5Dmm.



SAVE 19%

$16

H 1800

Kwik Crimp Multi-Pack

160pc assortment of popular crimp connectors. Great for auto-electrics.

S 5640

SAVE 14%

$30

Fuse Multi-Pack

Contains 18 of our most popular fast blow fuses with 10 of each value. Includes M205, 3AG & regular blade types.

P 7823

NEW!

$7.95

EC5 Style DC Plugs

60A rated high current 5mm battery plugs

P 7825

NEW!

$8.95

XT90 Style DC Plugs

90A rated version of the popular XT60.

Benchtop Savings.

$145 SAVE $54

M 8263 9-15V 30A

$119 SAVE $40

M 8261 9-15V 20A

Analog Lab Power Supplies

These compact, fan cooled, switchmode power supplies deliver up to a huge 30A regulated output, adjustable between 9 and 15V. Plus fixed 13.8V setting. Low noise design. 85% efficient. 155x70x205mm.

2 Year Warranty.

Q 1536

$199 SAVE $60

High Accuracy 2.7GHz Frequency Counter

Covering a range of 10Hz to 2.7GHz in two ranges: 10Hz to 100MHz and 100MHz to 2.7GHz. Ideal for servicing and calibrating RF equipment, radio mics, CBs & transceivers. Period, frequency, pulse count (totalise) functions. x20 input.

A must have for the servicing workbench

Q 1520

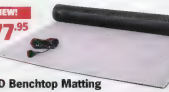
$239 SAVE $60

UNI-T® True RMS Benchtop DMM Datalogger

Ideal for service departments & circuit development. Provides true RMS measurement & datalogging. 240V or battery powered (6 x C Cells). • 10A AC/DC • Freq. to 50MHz • Temperature • Software, temp probe, PC USB/serial leads included • 2 year warranty.

NEW!

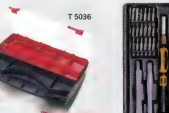
$77.95



T 4036

ESD Benchtop Matting

Fend off static from your workspace. Includes grounding cord. 1200mm x 600mm. Grey colour.



T 5036

SAVE 20%

$29

Two Sided Parts Case

Nifty parts case with adjustable dividers for up to 15 compartments on one side, plus 10 removeable containers. 340x280x80mm.

T 2164

NEW!

$29.50

Smartphone Repair Kit

Everything you need to disassemble and repair most smartphones and tablets. See web for contents list.

Latest Audio Visual Accessories...

A 2691A

Opus One® 2x100W Stereo Amplifier Receiver

$299 SAVE $76

Expand your home audio system to the study or entertainment area. Features six stereo inputs, AM/FM tuner and A/B speaker selection. Includes remote.

Bluetooth Stereo Amplifier Wallplate

NEW! $129

Wireless audio streaming from your smartphone, direct to the wall controller. 2x15W RMS stereo amplifier built in, great way to install speakers in the study or games room.

In-built FM tuner & USB/SD card music input

A 1100

Great for pairing with ceiling speakers in the study!

HANDY! NEW! $129

A 3216A

Long Distance HDMI Sender

Send 1080p signal from your Blu-Ray or game console up to 50m over Cat5e/6 UTP. Includes transmitter, receiver & plugpacks.

USB Charger & Bluetooth Receiver

Combines a 1A USB charger for keeping your phone topped up with a Bluetooth audio streamer for direct connection to your amp or active speakers.

NEW! $49.95

A 1109

A 3134C SAVE 20% $55

Two Way HDMI Splitter

Allows you to view one HDMI source to two monitors. Works with 4K/2K displays.

SAVE 25% $44

A 1171A

Infra-Red Extender Kit

Includes hub, two dual eye emitters, target and plugpack. Foxtel compatible. Easy to set up!

NEW! $89.95

A 3834

Upscale 1080p to 4K

Scales 1080p to 4K/2K resolutions & splits off optical audio for connection to other devices.

A 3830A SAVE 15% $69

Handy problem solver!

Extract Audio from HDMI

Ideal for connecting HDMI sources to non-HDMI amplifiers, active speakers etc. Optical and 3.5mm stereo outputs. Includes plugpack.

Lightweight, Compact 2 Ch DJ Mixer

Great for beginners and mobile DJs requiring a robust lightweight mixer. Two pairs of switchable phono and line inputs, plus stereo record and amp outputs. Bass, treble and gain adjustments. Cue crossfader makes it easy to cue upcoming tracks. Includes power supply.

$99 SAVE $36

A 2544

SAVE $20 $79

S 9359

5.8GHz Wireless AV Sender

• Transmit stereo audio & composite video without cables from room to room • 30m range • IR sender built in • Includes transmitter, receiver & plugpacks.

$169 SAVE $30

A 4198

4 stereo 30W amps in one!

4 Zone 30W Amplifier

Ideal for multi-zone audio distribution. Offers 30W RMS per zone (15W per/ch) all from a unit measuring just 200mm wide! Individual volume controls. Headphone output. RCA input. **Includes power supply.**

SAVE 20% $49

C 0384

All metal construction

Entertainer Microphone

Low noise & feedback design. Includes 4.5m XLR 3 pin lead.

C 0993 10" 180W SAVE $60 $199

C 0991 8" 100W SAVE $40 $155

Instant sound system!

Address Large Crowds With Ease

An all in one portable PA unit with amp that sets up in just seconds - no expertise required. Just plug into 240V power, switch it on and connect a mic. USB playback makes it easy to play your favourite tunes. Great for clubs, sports events, fetes, carnivals and bingo nights!

Great for use with a TV or PC!

C 5060 $199 TOP VALUE

Microlab® SOLO-6C Active Bookshelf Speakers

Unbelieveable sound for a bookshelf system under $200. Perfect for music, gaming & TV. Requires no external amplifier. Hear a demo in-store!

Stunning Home Hi-Fi In Ceiling/Wall Speakers

Add superb presence and clarity to your home sound system with these 8" (200mm) low profile speakers. Aluminium grilles are suitable for mounting in sheltered outdoor alfresco and entertaining areas. 100 Watts. **Sold in pairs.**

Easy flip-lock installation!

SAVE $80 $219 C 0883 Round

SAVE $80 $249 C 0881 Rectangular

FREE! Pair of premium Opus One® C 3088 8" subwoofer drivers. Valued at $118

See website for suggested enclosure.

$189 BONUS DEAL

Do-It-Yourself Active Subwoofer Module

The same high performance as our popular C 5201 Opus One cinema subwoofer! DIY subwoofer amp equipped with volume, crossover frequency control, phase switch, high and low level outputs. 120W RMS, stable into 4 ohms. **A 2451**

ALTRONICS
BUILD IT YOURSELF ELECTRONICS CENTRE

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Build It Yourself Electronics

K 5528

Currawong 2x10W Valve Amplifier Kit

The Currawong amplifier is a tried and tested valve amplifier circuit which has been adapted to components which are readily available. Each channel uses two 12AX7 twin triodes for the preamp and phase splitter stages and two 6L6 beam power tetrodes in the class-AB ultra-linear output stage. It performs very well, with low distortion and noise.

Features: • Two pairs of 6L6 beam power tetrodes • Two pairs of 12AX7 twin triodes • 2x10W RMS power output into 8 Ohm loads • Remote volume control

Supplied with: This kit includes all valves, PCB, componentry, acrylic board cover, transformers & panels. It **does not** include parts to build the enclosure. We suggest building your own to suit your own style.

K 2533

LC Test Meter Kit

(SC May '08) Great for testing capacitors and inductors with unknown values. The perfect addition to the technician's tool box! Inductance: 10nH-70mH. Capacitance: 0.1pF-80nF. Requires 9V battery.

K 1688

Check Battery Condition Instantly

(SC Aug '09) Checks condition of 6, 12 and 24V cells . Suits lead acid & sealed lead acid batteries. Lets you know in an instant if your battery needs a zap!

K 2543

Audio Oscillator Kit

(SC June '09) Adjustable 10Hz to 30kHz output in sine, square, triangle and sawtooth waveforms for testing amplifiers, speakers and other audio devices. Three ranges: 20mV, 200mV & 1V. Requires 9V battery.

K 2558

Capacitor Leakage Meter Kit

(SC Dec '09). Performs leakage testing on almost any capacitor type. A valuable piece of gear for servicing. Leakage current 10mA-100nA. Seven test voltages (10-100V). Requires 6 x AA batteries.

K 2574

ESR Meter MK-II Kit

(SC April '04) Allows quick "in-circuit" detection of defective electrolytic capacitors. 0.01-99Ω autoranging. A must have for technicians.

K 2556

Megohm Meter Kit

(SC Oct '09). Ideal for checking insulation breakdown in wiring. 500V/1000V range. Reads up to 999MΩ & leakage currents below 1μA. Requires 4xAA batteries.

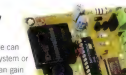
K 5332

Audiophile Digital-Analog Converter Kit

(SC Sept-Nov '09) This quality kit will drastically improve the sound output from a CD/DVD player, set-top box, PVR or computer, allowing you to obtain audiophile quality sound. Also reduces buzz, hum and signal noise. Coaxial or optical inputs. RCA output. Includes all components and metal case.

Keyless Door Entry System Kit

(SC June '04) This module can be interfaced to an alarm system or door lock. Up to 24 users can gain access by simply waving a coded tag near the receiver. Includes keyfob tag, extras $4.95 (S 5376). Card tags $4.95 ea (S 5375)



K 9300

Resistance & Capacitance Decade Box

(SC Aug '14) This decade box kit is a really handy device for trying capacitor and resistor values in-circuit before you select the final value to solder.

K 7520

Take amazing stop motion photos

(SC Jan '09) Flash Camera Trigger Kit. Take pictures at precise moments from 1ms to 9.99s after a trigger. Triggering can be from the included electret mic or other sensors. Requires 9V battery.

K 6009

Remote Switch Timer Kit

(SC November '14)
Schedule your appliances to turn on and off with this handy kit, designed to be used in conjunction with the Altronics A 0340 remote mains switch (included).

K 6130

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Esperance	Esperance Comms.	(08) 9071 3344
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Please Note: Resellers have to buy the stock, freight and insurance and therefore the range of stocked products & prices (ranges) for individual resellers may vary from our catalogue.

9-Channel Infrared Remote Control

Using a tiny, prebuilt 9-button remote, this infrared remote control receiver is ideal for use with TVs, hifi & audio-visual equipment, model train layouts and for robot control. Not only that but the one tiny handheld remote can be used to control up to three separate receivers, each with seven channels. No surface-mount parts are used in the design and it can run from a 12V battery or DC plugpack.

By JOHN CLARKE

INFRARED REMOTE controllers are great but most universal remote controls tend to have lots of pushbuttons to cater for numerous functions and are quite bulky. If you only need a few functions, a much smaller remote is a lot more convenient.

That is why this project uses a tiny IR remote from Sparkfun in the USA and available in Australia from Littlebird Electronics. Normally sold for use in Arduino projects, it's used here with a dedicated receiver which controls up to nine output channels. Alternatively, it can control three independent receivers, with up to seven outputs each. That might sound a little confusing but the upshot is that this is a powerful control system with lots of options.

The Sparkfun IR remote measures only 80 x 40 x 7mm and is powered by a 3V lithium CR2025 button cell. It has nine snap-action pushbuttons: on/off (shown with the Power logo), A, B and C, and a 5-switch array with "OK", up, down, left and right. The 5-button array is ideal for volume and channel selectors or forward, reverse, left and right functions (eg, in a model railway system).

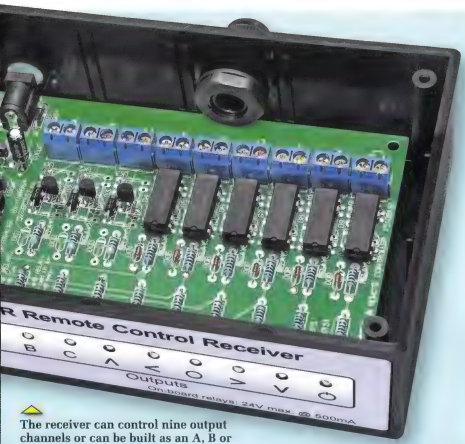
The Sparkfun remote comes fully assembled and uses a 16-pin surface-mount IC, type HB8101P. It sends a unique code via an infrared LED for each of the nine pushbuttons. The infrared signal is in 38kHz bursts, in a format known as "Pulse Distance Protocol". The controller has nine corresponding outputs and one of these will be switched if a valid code is received.

The nine outputs can be switched by reed relays, open-collector transistors or a combination of both. The transistor outputs can be used to directly switch LEDs or to switch relays with higher contact ratings than those of the on-board reed relays.

By the way, you don't need to build the controller with all nine outputs if you don't need them; just build it with as many as you need.

Momentary or toggle?

Each output can be set for momentary or toggle (sometimes called alter-



The receiver can control nine output channels or can be built as an A, B or C device with seven output channels.

Features & Specifications

Features

- Uses pre-built miniature 9-button hand-held remote
- Nine output channels (single receiver unit)
- Optional A, B or C device (receiver) addressing with seven channels per device
- Reed relay outputs or open-collector outputs (suitable for a 12V DC coil relay)
- LED indicators
- Momentary or toggle operation on each output

Specifications

- IR reception range: 15m
- Power: 12VDC at 150mA minimum (increase the current rating for any added relay coil current)
- Output ratings: Reed relay contacts or open collector outputs, 24V @ 500mA.
- IR coding: Pulse Distance Protocol
- Reception frequency adjustment: ±12.5% in 16 steps (~1.5% steps)

nate) operation. Momentary operation is where an output and its associated indicating LED is switched on only while the button for that function is being pressed. It goes off immediately when the button is released.

For toggle operation, an output is set to switch on with one press of an IR remote button and it will stay on until the same button is pressed again; a further press of the button switches the output off again.

A pushbutton switch on the controller board is used to select momentary or toggle operation for each individual output and the unit remembers this

INTO RADIO?

How about SiDRADIO?

Take a Cheap DTV Dongle and end up with a 100kHz-2GHz Software-Defined Radio!

Published October 2013

Don't pay $$$$ for a commercial receiver: this uses a <$20 USB DTV/DAB+ dongle as the basis for a very high performance SSB, FM, CW, AM etc radio that tunes from DC to daylight!

Features:

- **Tuned RF front end**
- **Up-converter inbuilt**
- **Powered from PC via USB cable**
- **Single PCB construction**

Lots of follow-up articles, too!

Want to know more? Search for "sidradio" at siliconchip.com.au/project/sidradio

PCBs & Micros available from On-Line Shop

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miniMaximite

or

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Parts List

1 double-sided PCB, code 15108151, 132 x 87mm
1 front panel label, 148 x 45mm
1 9-button IR remote control, (LittleBird Electronics, Sparkfun COM-11759) – see either: http://littlebirdelectronics.com.au/products/infrared-remote-control or http://littlebirdelectronics.com.au/products/ir-control-kit-retail
1 CR2025 3V alkaline cell
1 UB1 plastic case, 158 x 95 x 53mm
1 SPST micro-tactile switch with 0.7mm (or similar length) actuator (eg, Jaycar SP-0600) (S1)
1 12V DC plugpack rated at 150mA or more (see text)
1 2.1mm or 2.5mm PCB-mount DC socket to suit plugpack (CON10)
9 2-way screw terminals, 5.08mm pitch (CON1-CON9)
1 cable gland to suit wiring
1 18-pin DIL IC socket
1 3-way DIL header (2.54mm spacings)
1 jumper shunt for header
3 PC stakes (TP GND, TP1, TP2)

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 1510815A.HEX (IC1)
1 TOSOP4838 or equivalent 38kHz IR receiver (IRRx1) (Jaycar ZD1952, Altronics Z1611A)
1 78L05 5V 100mA regulator (REG1)
9 high brightness 3mm red LEDs (LED1-LED9)
1 high brightness 3mm green LED (LED10)
1 1N4004 1A diode (D10)

Capacitors

2 100µF 16V PC electrolytic
1 10µF 16V PC electrolytic
1 100nF MKT polyester

Resistors (0.25W, 1%)

10 1kΩ 1 470Ω 1 100Ω

Reed relay outputs*

9 SPST DIP 5V reed relays (Altronics S4100A, Jaycar SY-4030) (Relay1-Relay9)
9 1N4148 diodes (D11-D19)
9 100Ω 0.25W, 1% resistors

Open collector outputs*

9 BC337 NPN transistors (Q1-Q9)
9 1N4004 diodes (D1-D9)
9 470Ω 0.25W, 1% resistors
LK1-LK9 = resistor lead off-cuts

** Adjust part numbers required for a mix of reed relay and open collector outputs*

setting even if the power is switched off. Note that all the outputs are always initially off whenever power is applied to the controller.

Three separate devices

As already noted, the Sparkfun remote can be used to select and control up to three separate devices, designated A, B and C. But if you want three separate devices, you need three separate receivers. So to select one of the three devices, you press button A, B or C on the remote and then the remaining buttons on the remote can be pressed to control the various functions on the selected receiver.

The receiver incorporates three jumper positions that allow it to be set as an A, B or C device.

Alternatively, if you don't need to control multiple receiver units, you simply leave out the jumper. In this mode, all nine outputs in the receiver unit are active and can be controlled by the remote.

Circuit details

Now have a look at Fig.1 which shows the circuit details of the controller. It employs an infrared receiver/decoder (IRRx1) and a PIC16F88-I/P microcontroller (IC1) which directly drives reed relays, NPN transistors or a combination of both, depending on how you configure the PCB.

IRRx1 is a 3-lead device that comprises an infrared detector, amplifier, 38kHz bandpass filter and automatic gain control (AGC). Normally, IRRx1's output is high (5V) and it goes low when it receives a 38kHz IR signal. The supply for IRRx1 is derived via a 100Ω resistor from the 5V rail and is decoupled by a 100µF electrolytic capacitor.

IRRx1's output connects to the RB0 input of IC1. IC1 in turn decodes the 38kHz signal to drive the outputs according to the handheld remote. Each output comprises an indicator LED driven via a 1kΩ resistor and either a 100Ω resistor which drives a reed relay or a 470Ω resistor which drives the base of an NPN transistor.

Note that wherever a reed relay is used, a reverse-biased diode (D11-D19) is used to clamp any transient voltage from the relay's coil when it is switched off.

By contrast, if a transistor is used instead, a diode (D1-D9) is used to clamp any transients from an external relay. Whenever the transistor is turned on, the external relay is enabled (turned on). Note that the circuit shows one output driven from RB1 (pin 7) and one driven by RA1 (pin 18) but seven other outputs are also available, depending on whether you install the relevant components on the PCB.

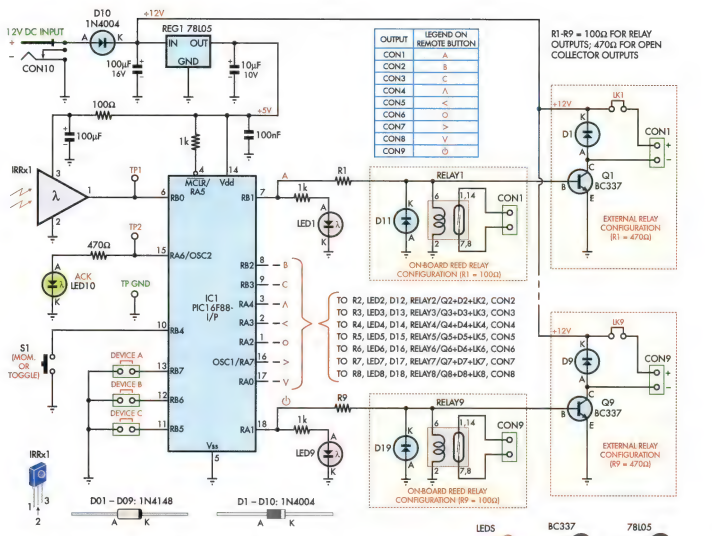
The acknowledge LED (LED10) is driven via IC1's RA6 output and flashes whenever an infrared signal is received. It's turned on when signal from IRRx1 is detected by IC1 as a low and is off when IRRx1's output is high.

In addition, LED10 does double-duty as a power indicator. When power is applied, it briefly flashes every second (ie, at a 1Hz rate) but flashes rapidly if an IR signal is received by IRRx1.

The RB4, RB5, RB6 & RB7 inputs are normally high (+5V) unless pulled to 0V via momentary pushbutton switch S1 (for RB4) or the link options for the A, B or C inputs at RB7, RB6 & RB5. Only one jumper shunt should be used if the controller is to be used in its device mode (ie, with A, B or C). If more than one jumper is connected, say A and B, only A will be recognised.

Note that if the Device A jumper is installed, then outputs B & C are disabled while the others all function normally. However, pressing either button B or C on the remote will always turn the A output off (if it's on), while the other outputs will be left in their current state. These outputs will then not respond to further button presses on the remote unless the Device A button on the remote is pressed again.

The Device B and Device C jumper options work in similar fashion, ie, a Device B jumper selection disables the receiver's A & C outputs, while a Device C jumper selection disables the A & B outputs.



9–CHANNEL IR REMOTE CONTROL RECEIVER

Fig.1: the circuit is based on infrared receiver/decoder (IRRx1) and a PIC16F88-I/P microcontroller (IC1). IC1 decodes the signal from IRRx1 and its outputs drive either reed relays (Relays1-9) or open-collector transistors (Q1-Q9). LEDs1-9 provide channel on/off indication, while the jumpers at IC1's RB5-RB7 inputs provide optional device selection.

If no device jumper is fitted, then no channels are disabled and the remote controls all of the receiver's outputs.

Frequency adjustment

While the handheld remote and the controller are designed to operate with Pulse Distance Protocol, the actual times for each 38kHz burst and the off times can vary from specification. This is due to tolerances in the clocking rate for the code transmission and in measuring the transmission time periods.

That's because both the transmitter and controller ICs run using internal oscillators that are not precise. We have dealt with that by arranging for the microcontroller's software to cater for up to a 10% variation in frequency for the transmission rate and the detected time period. However, in some cases this may not be sufficient to reliably detect and decode transmissions.

If that is the case, the software controller allows IC1's internal oscillator to be shifted in frequency. The available range of correction is ±12.5%, with adjustment steps in either direction of about 1.5%.

All of the relays and/or transistor outputs are powered from the +12V rail which is fed via reverse-polarity protection diode D10. The 5V supply for IRRx1 and IC1 comes from REG1, a 78L05 regulator. Its input and output are bypassed with 100µF and 10µF capacitors, respectively. In addition, IC1's supply is bypassed with a 100nF capacitor close to the supply pins.

Construction

Building the Remote Control Receiver is easy, with all parts installed on a PCB coded 15108151 (132 x 87mm). This is housed in a UB1 plastic case measuring 158 x 95 x 53mm, while a 148 x 45mm panel label is affixed to the side.

Figs.2 & 3 show the parts layouts for two different versions. Follow Fig.2 to build the unit with reed relay outputs or Fig.3 if you want open collector transistor outputs (eg, to switch external relays).

Alternatively, you can have a mix of relay and open-collector outputs. It's

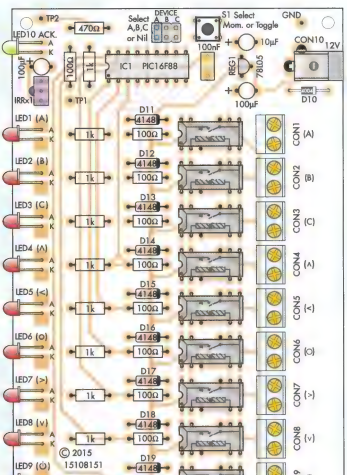


Fig.2: follow this PCB layout to build the unit with reed relay outputs. A jumper is shown here in the Device A position but this should be omitted if you only want a single 9-channel receiver.

just a matter of referring to either Fig.2 or Fig.3 and installing the appropriate output components for that channel.

As shown in the photos, our prototype was built with open-collector transistors for outputs A, B & C and reed relays for the remaining six outputs. Note that the output channel symbols match the buttons on the remote control.

Note also that if you plan to set the controller for device operation, you don't need to fit the output components for the disabled channels. For example, if the controller is to be an A device, then the B and C output components (including LEDs 2 & 3) do not need to be installed.

Similarly, you can leave out the output components for any other channel that isn't required but note that LED1 is required for Device A operation since this is the Device A indicator. Alternatively, you will need to install LED2 for Device B operation or LED3 for Device C operation.

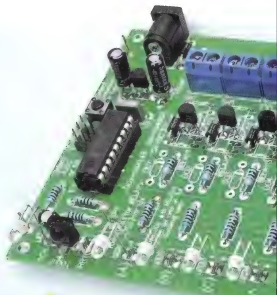
If sorting that out all sounds too hard, then you can just install all the parts for each output channel.

Begin the assembly by fitting the resistors. Table 1 shows the resistor colour codes but you should also check their values using a DMM before soldering them to the PCB.

Be sure to fit the correct values for resistors R1-R9. 100Ω resistors must be installed for the reed relay channels, while 470Ω resistors are used with the open collector transistors.

The diodes go in next. Note that D11-D19 on Fig.2 are 1N4148 types, while D1-D9 on Fig.3 are 1N4004s and occupy different positions. D10 is a 1N4004 on both versions. Take care to ensure that the diodes are all orientated correctly.

Next, fit the PC stakes for TP1, TP2 and TP GND, then install an 18-pin DIL socket for IC1 (notched end to the left). The capacitors can then be soldered in place, taking care to ensure that the three electrolytics are orien-



Our prototype PCB was built with open collector transistors for outputs A, B & C and reed relays for the remaining six outputs.

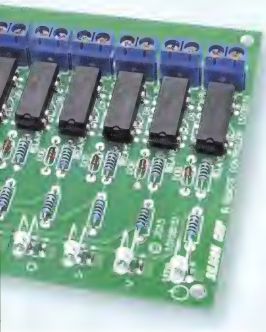
Front Panel Labels

The front-panel label is optional. It can be made by downloading the relevant PDF file from the SILICON CHIP website and then printing it out as a mirror image onto clear overhead projector film (use film that's suitable for your printer). By printing a mirror image, the toner or ink will be on the back of the film when it's fitted. The label can be secured in place using white or grey silicone adhesive.

Alternatively, you can print onto a synthetic Dataflex sticky label if using an inkjet printer or onto a Datapol sticky label if using a laser printer.

(1) For Dataflex labels, go to: www.blanklabels.com.au/index.php?main_page=product_info&cPath=49_60&products_id=335

(2) For Datapol labels go to: www.blanklabels.com.au/index.php?main_page=product_info&cPath=49_55&products_id=326



tated correctly. The 100nF polyester (MKT) capacitor can be fitted either way around.

Follow with the DC socket and switch S1, then install transistors Q1-Q9 (as required) and regulator REG1. Links LK1-LK9 can now be installed in those channels where a transistor is fitted. These links are only very short (less than 5mm) and can be fashioned using resistor lead off-cuts.

The 3-way DIL header for device selection is installed near IC1. Its short pin lengths go into the PCB, while the longer pin lengths on top accommodate the jumper shunt (if fitted).

Screw-terminal blocks CON1-CON9 can now all be installed. Make sure that they sit flush against the PCB and that their wire entry holes are to the right before soldering their pins.

LEDs & infrared detector

Fig.4 shows how the LEDs are installed. As shown, their leads must be bent down by 90° exactly 6mm from their bodies and that's best done using a 6mm-wide cardboard template. **Make sure that each LED's cathode (K) lead (the shorter of the two) is facing**

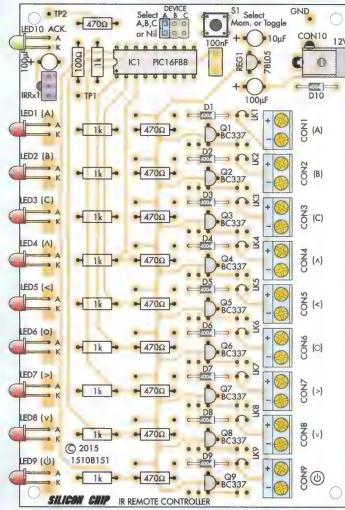


Fig.3: here's how to build the unit with open-collector transistor outputs. You can have a mixture of outputs on the same board if you wish – just configure each channel according to the relevant PCB layout diagram.

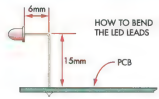


Fig.4: each LED has its leads bent down through 90° exactly 6mm from its body before installation on the PCB. That's best done using a 6mm-wide cardboard template. Note that the LEDs are soldered to the PCB only after the latter has been installed in the case (see text).

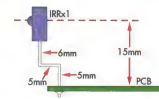


Fig.5: the diagram shows how to bend the leads of infrared receiver IRRx1. Bend the leads around 5mm and 6mm-wide cardboard templates and make sure that the centre of the lens is 15mm above surface of the PCB when soldering the device in place.

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	10	1kΩ	brown black red brown	brown black black brown brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown

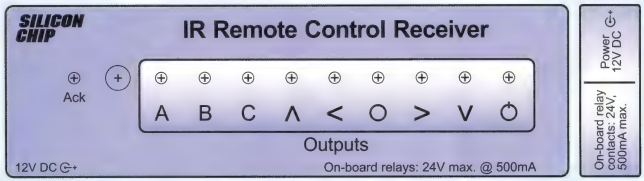


Fig.6(a): use this front-panel artwork if you are building a single unit to control nine output channels. It can either be copied or downloaded in PDF format from the SILICON CHIP website and printed onto clear film or a sticky label (see text). The rear panel artwork is shown to the right.

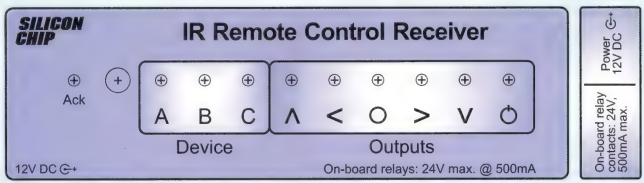


Fig.6(b): use these artworks if you are building more that one receiver and will be using device selection. Note that either of the above two front-panel artworks can be used as a drilling template for the case.

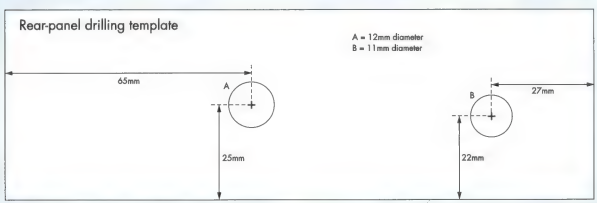


Fig.7: this is the rear-panel drilling template. The two holes are best made by first drilling small pilot holes and then carefully enlarging them to size using a tapered reamer.

towards you before bending its leads down, so that the LEDs go in with the correct polarity.

Don't solder the LEDs to the PCB at this stage though – that step comes later, after the PCB has been installed in the case.

Having prepared the LEDs, you can now bend the infrared detector's leads as shown in Fig.5. Again, that's best done using cardboard templates, one 6mm wide and the other 5mm wide. Use the 6mm template to first bend the leads back by 90°, then use the 5mm template to bend them back down again.

Having bent IRRx1's leads to shape, solder it in place with the centre of its lens exactly 15mm above the PCB. Fig.5 shows the details.

Drilling the case

The assembled PCB (minus the LEDs) can now be put aside while you drill the UB1 plastic case. Figs.6(a) & (b) show the alternative front panels for the receiver and you can make a photocopy and use either one as a drilling template. Alternatively, you can download the labels as a single PDF file from the SILICON CHIP website and print them out.

You need to drill 3mm-diameter holes for the 10 LEDs and a 6mm hole for infrared receiver IRRx1. Deburr all holes using an oversize drill, then drill two holes in the rear panel using the template shown in Fig.7 – one to provide access to the DC socket and the other to mount a cable gland.

The DC socket hole has a diameter of 11mm, while the cable gland hole is

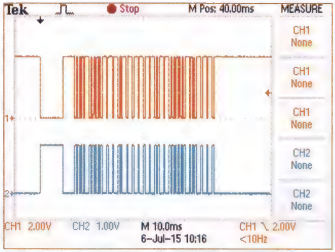


Fig.8: the top trace of this scope grab shows the output from IR detector IRRx1, while the lower trace is the Acknowledge LED voltage and shows the processed and decoded signal from the microcontroller. The initial 9ms pulse and 4.5ms gap indicate the start of the sequence (note: the coding shown is for the remote's power button).

The rear panel carries the cable gland and also has an access hole for the DC power socket.

12mm in diameter. They are best made using a small pilot drill to begin with and then carefully enlarged to size using a tapered reamer.

Now take a look inside the case. You will find that one of the LED holes goes through one the internal plastic ribs, while another hole will be immediately adjacent to one of these ribs. **You will need to cut away the ribs from around these holes using sharp side cutters, so that the LEDs will later fit correctly.**

Final assembly

Once all the holes have been drilled, the PCB can be slid into the case and clipped into the slots in the integral side ribs. Check that the PCB is the right way

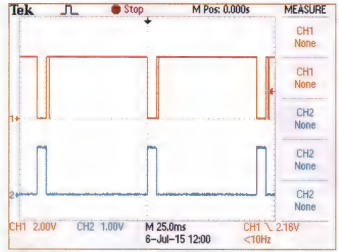


Fig.9: this scope grab shows the button repeat signal pulses. The top trace is IRRx1's output, the lower trace is the Acknowledge LED's decoded output.

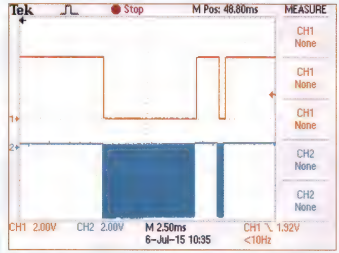


Fig.9: the bottom trace here shows the bursts of 38kHz signal as sent by the remote's IR LED, while the top trace is the demodulated output from IRRx1. Note that IRRx1's output is low when the 38kHz IR signal is present.

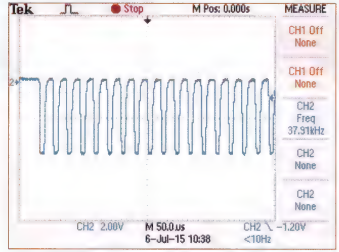


Fig.10: this shows an expanded view of the IR signal's 38kHz carrier frequency. The carrier is sent as a series of on and off pulses; ie, it's switched on and off with a particular pattern to identify a particular button.

This view shows the completed remote control receiver. It's powered using a 12V DC plugpack rated at 150mA or more.

Compensating For Frequency Tolerances

Normally, you will not need to compensate for transmission rate tolerances. However, if the receiver fails to operate reliably, you will need to adjust IC1's clock rate. The procedure is as follows:

(1) Switch off the power to the receiver, then reapply power while holding S1 down.

(2) Continue holding S1 down; LED5 (the centre LED in the row on nine) will light to indicate the current oscillator setting (this is the default "zero change" setting).

(3) Release S1; LED 5 will turn off and the Acknowledge LED (LED10) will turn on to indicate that the receiver is now in the oscillator adjustment mode (it can still flash if it receives a signal from the remote).

(4) Press switch S1 again. LEDs 5 & 6 will now both light to indicate that IC1's oscillator frequency has been slowed.

(5) Release S1 and test the receiver using the remote to see if it now operates reliably. In not, press S1 again; LED6 will now be lit on its own, indicating a further slowing of the oscillator frequency. Check the unit once again to see if it now operates reliably.

(6) Pressing S1 again will now light LEDs6 & 7, then LED7 on its own, then LEDs7 & 8 and so on up to LED9, with each step progressively slowing IC1's oscillator. Check for reliable operation after each step.

(7) Pressing S1 after LED9 has been lit moves the display back to the left (ie, towards LED1). When LED5 is reached, pressing S1 again will light LEDs5 & 4. This indicates that the frequency has been increased by one step from the default value. Further presses of S1 then light LED4, then LEDs4 & 3, then LED3 on its own, then LEDs3 & 2 and so on, with each step increasing the frequency.

(8) Once you've found a setting that gives reliable operation, switch off and then reapply power to get out of the frequency adjustment mode. The Acknowledge LED should now resume normal operation (ie, it will flash briefly at a 1Hz rate to indicate that power is applied, or flash rapidly if a signal is received from the remote).

around – the pads for the LEDs must be adjacent to LED holes in the side of the case.

The 10 LEDs can now be fitted in place and their leads soldered to their pads on the top of the PCB. Check that each LED is correctly orientated and that it protrudes through its front-panel hole before soldering its leads. LEDs1-9 are all red LEDs while LED10 (Power/Acknowledge) is green.

Now check that the infrared detector's lens is correctly aligned with its front-panel hole. If not, bend its leads until it's centred.

Testing

Now for the smoke test. Apply power using a 12V DC plugpack and check that the voltage between pins 14 & 5 of IC1's socket is close to 5V (4.85-5.15V). If no voltage is present, check diode D10's polarity and check the polarity of the plugpack supply (the centre of the plug should be positive). Make sure also that REG1 is correctly orientated and that all leads have been correctly soldered to their PCB pads.

If the supply checks out, switch off and install IC1, making sure that its notched end faces towards LED10 and that all its pins go into the socket correctly. That done, reapply power and check that the hand-held remote can activate each output.

By the way, you will need to insert a CR2025 cell into the remote before using it. The cell's tray is accessed from the bottom edge of the case. It's opened by first pulling its locking tab sideways (towards the centre) and then sliding the tray out (it may require some force to move it). The cell is then installed with its negative side towards the pushbutton (top) side of the case.

By default, the outputs are all config-

Driving Devices Using The Open Collector Outputs

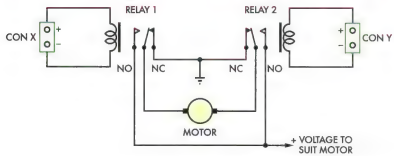


Fig.11(a): using two open collector outputs to drive a motor in both directions:

(1) Both outputs set for momentary operation
Pressing (and holding) the button for open-collector output "X" activates Relay 1 and causes to the motor to rotate one way, while pressing the button for output "Y" activates Relay 2 and causes the motor to rotate the other way.

(2) Both outputs set for toggle operation
The motor will be stopped until one of the outputs is toggled (its direction will depend on which output is turned on). The motor can then be reversed by toggling both outputs or stopped by toggling either output.

(3) One output set for toggle and the other momentary operation
The motor will run continuously in one direction if the toggle output is on or in the other direction for as long as the momentary output is on while the toggle output remains off (ie, it runs while the button on the remote is pressed).

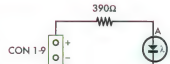


Fig.11(b): driving a LED output.

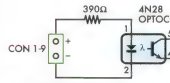


Fig.11(c): driving an optocoupler.

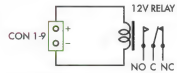


Fig.11(d): driving a 12V relay.

ured for momentary operation. **If you want toggle operation for an output, press and hold S1 on the receiver's PCB, then press the required button on the remote and release S1.** Switching back from toggle to momentary operation is done the same way

If you find that the unit doesn't operate reliably, or only works with certain orientations of the remote, it may be due to frequency tolerances. In that case, it's just a matter of altering IC1's frequency to improve the IR code detection. The accompanying panel (Compensating For Frequency Tolerances) describes how that's done.

If the unit fails to work at all, check your soldering and check that all parts have been correctly placed and orientated.

Front panel

Assuming that it's all working correctly, all that remains now is to fit the front panel. As shown in Figs.6(a) & 6(b), there are two to choose from. Use Fig.6(a) if you are simply using the unit to control nine output channels and don't need device selection (ie, you don't need to select another receiver).

Alternatively, if you are using device selection (eg, you have two or more receivers), use the front panel shown in Fig.6(b). Don't forget that you will need to install a jumper on the 3-way pin header (near IC1) on the PCB to select either device A, B or C.

An accompanying panel describes how to make a front panel using ei-

Pulse Distance Protocol (PDP)

Most infrared (IR) controllers use a modulation frequency somewhere between 36kHz and 40kHz – typically 38kHz. This is the frequency at which an infrared LED is switched on and off when a signal code is sent to the receiver.

A series of 38kHz signal pulses is called a "burst" and is inter-spaced with a pause during which no IR signal is sent. This series of bursts and pauses usually conforms to a particular format or protocol and there are several in common use. These include the Manchester-encoded RC5 and RC6 protocols as used by Philips, while Sony uses the Pulse Width Protocol.

By contrast, the remote used in this project uses NEC's Pulse Distance Protocol. Further details on all these protocols can be found in application note AN3053 by Freescale Semiconductor (formerly Motorola) – see: **http://cache.freescale.com/files/microcontrollers/doc/app_note/AN3053.pdf**

Fig.12 shows the basics of the Pulse Distance Protocol. Logic 1 and logic 0 both comprise an initial 560µs-long 38kHz burst. Each logic 1 is followed by a 1690µs pause but a logic 0 is followed by a shorter 560µs pause (ie, the same length as the logic 0's 38kHz burst).

The entire data stream uses a 9ms burst and a 4.5ms pause starting train. The following data consists first of the address bits and then the command bits. The address identifies the hand-held remote, while the command bits correspond to the buttons on the remote.

Note that the address and command data is sent with the least significant bit transmitted first. The data comprises an 8-bit address, after which a complementary 8-bit address is sent. This is essentially the opposite bit of the address that's sent. So for every "0" bit that's sent in the address, a "1" will be sent in the complementary address.

Similarly, for every 1 that's sent in the address, a 0 will be sent in the complementary address. The command bits are also resent in complementary form.

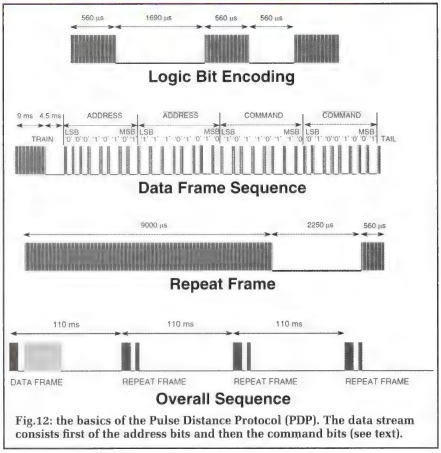


Fig.12: the basics of the Pulse Distance Protocol (PDP). The data stream consists first of the address bits and then the command bits (see text).

As an aside, if you look up the address and command values that the remote produces (see **https://learn.sparkfun.com/tutorials/ir-control-kit-hookup-guide**), you will see that the address is 10EF hex. In addition, the operate button code is D827 hex.

10 hex is the address value and EF hex is the address complement value. These values are in hexadecimal format (ie, values from 10-15 are designated A-F).

The complementary address and command bytes are sent so that they can be compared to detect errors. If the complementary data value received doesn't match the complement of the data value received, the signal has been corrupted somehow (eg, due to interference). Alternatively, the received data may not be PDP protocol data, which means that the signal is being sent by a different hand-held remote.

Following the address and command data, an end (or tail) comprising a 560µs burst is sent to complete the data frame. Any further holding of the hand-held remote's button will then produce a repeat frame. This consists of a 9ms burst followed by a 2.25ms pause and then a 560µs burst.

The repeat frame is repeated at 110ms intervals while ever the remote's button is held down.

ther clear film or a Dataflex or Datapol sticky label. Once you have the label, remove the PCB from the case, then affix the label in position and cut out the holes using a sharp hobby knife.

Output connections

The reed relays are ideal for switching low voltages (up to 24V maximum) and currents up to 500mA. They can be used to duplicate pushbutton switches on equipment by wiring the reed relay output in parallel with the switch.

If switching inductive loads, then a reverse-biased diode should be connected across the relay's contacts.

Do not under any circumstances use the on-board reed relays to switch mains voltages. That would be dangerous since neither the relays nor the PCB tracks are designed to handle high voltages.

If you do need to switch high voltages, use either the reed relay or the open-collector transistor outputs to switch appropriately-rated external relays. SC

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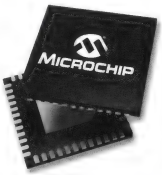

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Ultra-LD Mk.4 200W RMS Power Amplifier Module, Pt.2

By NICHOLAS VINEN

This month, we provide the construction details for our new ultra-low-distortion amplifier module. Most of the parts on the PCB are surface-mount types, keeping it compact and allowing for unprecedented low levels of distortion. We have avoided difficult-to-solder parts.

BY NOW, you should be familiar with the features, specifications and circuit details of our new Ultra-LD Mk.4 amplifier. This month, we're going to discuss some aspects of the PCB design, describe how we tweaked it to refine the performance and then go through the module assembly procedure.

PCB design

One advantage of the new PCB over the Mk.2 and Mk.3 designs is that we've totally eliminated all high-current vias, so there is no more concern about vias fusing under fault conditions and no wire feed-throughs are required. All high-current paths stay on the same side of the PCB.

The front-end control section is routed entirely on the top layer, with just

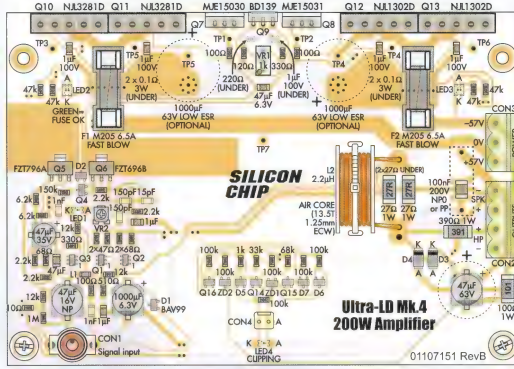


Fig.6: follow this layout diagram to install to parts on the top of the PCB. Fit the SMD parts first in the order listed in the text, then flip the PCB over and install the SMD parts on the bottom as shown in Fig.7. The remaining through-hole parts can then be fitted. Note that Q7-Q13 are soldered to the PCB only after they have been attached to the heatsink.

a few vias to connect components to the analog ground plane beneath. The remaining vias are arranged in pairs (or more) for redundancy and are mostly associated with either the clip detector circuit or the low-current power supply rails feeding the front end.

The +57V and -57V pins of power input connector CON3 are soldered to top layer tracks which run to SMD fuse-holders F1 and F2 respectively, on the top side of the board. These then connect to two further top layer tracks which go to the output transistor collector pins.

The output current at the emitter pins then runs along tracks on the bottom of the PCB to the 0.1Ω SMD emitter resistors, which are fitted directly underneath the fuse-holders. The current then feeds into another bottom layer track which combines the current from all four output transistors to through-hole air-cored inductor L2. A bottom layer track from the opposite end of L2 then connects to speaker output terminal CON2.

Construction

The double-sided PCB on which the Ultra-LD Mk.4 is built is coded 01107151 and measures 135 x 93mm. The output transistors mount on a diecast aluminium heatsink using the same layout as the Ultra-LD Mk.3 amplifier. The easiest way to build the module is to first fit most of the SMDs on the top side, followed by the eight SMDs on the bottom, then the remaining SMDs and on-board through-hole components and finally the heatsink-mounted transistors.

All the SMDs can be soldered using a regular soldering iron (ie, a pencil type) and solder wire as long as you have some solder wick and flux paste. Depending on your eyesight, you may also need a magnifying lamp or visor. A hot-air rework station or reflow oven can also be used although you will need to solder the fuse-holders and LEDs by hand as they can be damaged by excessive heat.

If you're assembling the unit from a kit which has the SMDs pre-soldered then you can skip this next section.

Soldering the SMDs

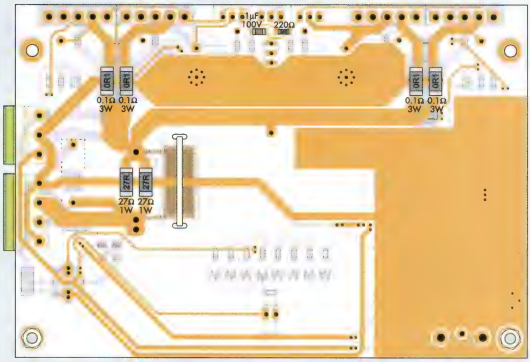
Fig.6 shows the parts layout on the top of the PCB. Begin by installing transistor Q2. This has a lead pitch of 0.95mm which is the finest of all the parts but it isn't particularly difficult. First, remove the HN2C51F from its packaging (don't drop it!) and inspect it under magnification to locate the pin 1 dot on the top.

Place it near its mounting location with the correct orientation. Make sure it's the right way up; the leads should be in contact with the PCB. Then flow a tiny amount of solder onto one of the corner pads on the board, without getting any solder on the other pads. Clean off the iron, grab the part gently with angled tweezers using your other hand, heat the solder on that pad and slide the part into place.

Put the iron away and use a loupe

WARNING!

High DC voltages (ie, ±57V) are present on this amplifier module when power is applied. **In particular, note that there is 114V DC between the two supply rails.** Do not touch the supply wiring (including the fuse-holders) when the amplifier is operating, otherwise you could get a lethal shock.



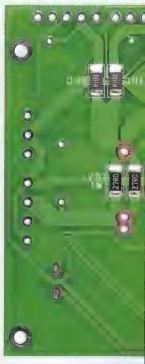


Fig.7: once you've installed all the SMD parts on the top side, flip the PCB over and follow this layout diagram to install the eight SMD parts on the underside. Note that the four 0.1Ω resistors must be rated at 3W, while the two 27Ω resistors must be rated at 1W (don't get these parts mixed up). Table 1 on the facing page shows the value code printed on the top of each SMD resistor.

or similar to check that all six pins are correctly positioned over their pads, the pin 1 dot is in the right location and the part is sitting flat on the board. If not, reheat the solder joint and fix the problem by gently nudging the component. For example, if it isn't sitting flat on the board, press down on it (not too hard) with the tweezers while heating the joint and it should drop into place. Alternatively, if it's misaligned, carefully rotate or slide it while heating the solder.

Once it's in place, solder the pins on the other side of the package. Don't worry too much about bridging them; just make sure that the solder flows onto all three pins and their associated pads. Then do the same for the three pins on the other side, including the one you tacked down initially.

Now it's simply a matter of applying a small amount of flux paste along both sides of the IC, then using solder wick to remove the excess solder. Clean off using a flux remover (methylated spirits or rubbing alcohol will do in a pinch) and inspect under magnification to make sure all six fillets have formed correctly. Be aware that solder can adhere to the pin without flowing onto the PCB pad below.

Once you're happy with it, fit Q1 and Q3 which are in identical packages.

Next, fit the 11 SOT-23 package parts: Q4, Q14-Q16, D1-D2, D5-D7 and ZD1-ZD2. These are similar to Q1-Q3 but with three widely-spaced leads. Use the same basic procedure; the correct orientation should be obvious as there is only one lead on one side of the package and two on the other. Do take care not to get the parts in the wrong place, though; if in doubt, refer to Fig.6.

Transistors Q5 and Q6 can go in next. These are in larger packages with three leads plus a tab for heatsinking and are soldered to large copper planes so this will require a fairly hot iron. Smear a little flux paste on the large pad, then position the component on the PCB and solder one of the smaller leads at either end. You can then solder the tab and finish with the two remaining leads. Make sure that the FZT796A goes on the left and the FZT696B on the right.

Now you can solder diodes D3 and D4 in place, with their cathode stripes towards the top of the board. These stripes are normally quite faint and you may need a magnifying glass to see them.

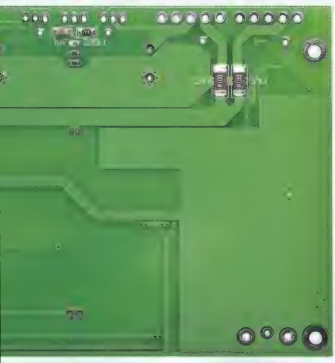
The four LEDs can go in next. If you're using the exact types we specified in the parts list last month, each will have a green cathode marking. However, some other SMD LEDs have similar markings at the anodes, so if using different types, check the data sheet or else use a DMM on diode test mode to figure out which end is the

Parts List Errata

In the parts list last month, the two VS-3EJH02 diodes were incorrectly listed as D2 and D4. They are D3 and D4.

In addition, the bobbin specified for the 2.2µH air-cored inductor (L2) was incorrectly specified as having a 10mm ID. It should be 13mm ID.

Finally, depending on how you choose to mount the transistors on the heatsink, you may need some additional hardware not listed last month, including three M3 x 10mm and four M3 x 15mm machine screws.



Above: this view shows the bottom of the PCB with all the SMD parts installed, before any of the through-hole components have been fitted. It's easier to mount these components before the larger parts are installed on the top side so that the PCB will still sit flat on the bench.

Table 1: Resistor Codes

No.	Value	3-Digit Code (E24)	4-Digit Code (E96)
1	1MΩ	105	1004
6	100kΩ	104	1003
2	68kΩ or 68.1kΩ	683	6812
4	47kΩ	473	4702
1	33kΩ	333	3302
3	12kΩ or 12.1kΩ	123	1212
2	6.2kΩ or 6.49kΩ	622	6491
4	2.2kΩ or 2.21kΩ	222	2211
2	1kΩ	102	1001
1	510Ω or 511Ω	511	5110
1	390Ω 1W	391	not applicable
2	330Ω or 332Ω	331	3320
1	220Ω or 221Ω	221	2210
1	120Ω or 121Ω	121	1210
1	100Ω 1W	101	not applicable
3	100Ω	101	1000
3	68Ω or 68.1Ω	680	68R1
2	47Ω or 47.5Ω	470	47R5
4	27Ω 1W	270	not applicable
1	10Ω	100	10R0
4	0.1Ω 3W	0R1	not applicable

anode and which is the cathode.

You can solder the SMD LEDs in place using a similar procedure as before, ie, tack down one side then solder the other. Don't get the different types mixed up. Note that LED2 and LED3 each have four terminals so avoid bridging the two at each end. If you do, use flux and solder wick to clean them up. Also make the joints quickly to avoid heating them for too long; these LEDs are quite small and can be damaged by heat.

In particular, the plastic lenses of the SMD LEDs can be damaged if the iron is held on them for too long or if the air temperature is too high. Be careful if using either hot air or infrared reflow.

Trimpot VR2 can go in next. Try to avoid getting solder on its metal adjustment plate. After that you can solder the top-side SMD resistors in place. Each will be printed with its value as a 3-digit or 4-digit code (see Table 1). The only resistors which are not fitted at this stage are one 220Ω 0.5W, two 27Ω 1W and four 0.1Ω 3W types.

Next, install all the SMD ceramics, except for one 1µF capacitor which goes on the bottom of the board. Ferrite bead L1 can also be fitted now.

There are a total of eight passive SMD components that go on the underside of the board; see Fig.7. Fit these now, using the same method as before.

Returning to the top side, the SMD electrolytic capacitors can now be mounted. These consist of a metal can on a plastic base with two flat leads and all but one have a black stripe on the top of the can to indicate the negative lead and a chamfered base on the side of the positive lead. Orientate each capacitor as shown in Fig.6 and use a similar procedure as for the ceramic types to solder them in place.

The last top-side SMD parts to fit are the two fuse-holders. These are quite large parts with high thermal inertia as they are soldered to large copper conductors. A fair bit of heat will be required but the procedure is otherwise similar to the other components. Note that the plastic portion can be damaged by too much heat.

Through-hole components

Now you can fit the through-hole components, other than the large transistors, in the usual manner. It's best to start with trimpot VR1, then follow with CON4 (if fitted), CON2, CON3 and CON1. For CON2 and CON3, we recommend that you orientate them so that when the terminal blocks are plugged in, the wire entry is from the right-hand side of the board. The easiest way to do this is to temporarily plug the terminals in just before soldering, to check the orientation.

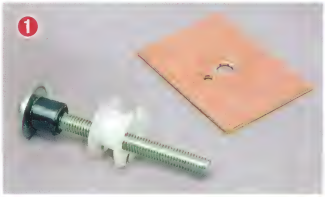
Note that depending on your amplifier chassis layout, it may be possible to mount these the other way around and have the wires come in over the PCB itself. However, we haven't tried this.

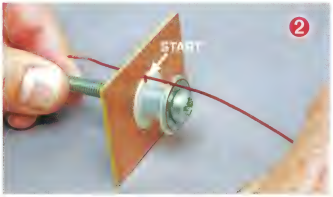
Now you can install the optional through-hole capacitors, if you are using these, with the exception of the 1000µF types which we'll leave for later. You will definitely need to fit the 47µF 63V electrolytic type if you have not already mounted its SMD equivalent, in the lower right-hand corner of the board.

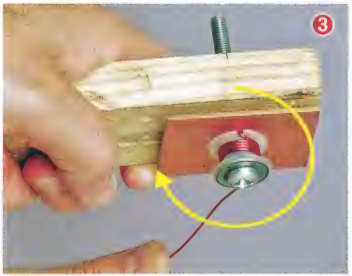
Similarly, if you are using a polypropylene capacitor for the output filter, rather than SMD NP0 ceramic, install it now.

You may fit PC stakes to the test points if you want to. This does make adjustments slightly easier as you can clip alligator leads onto them. However, if you do so, you will need to be

Making A Winding Jig For The 2.2μH Inductor







These photos show how the winding jig is used to make the 2.2μH inductor. First, the bobbin is slipped over the collar on the bolt (1), then an end cheek is attached and the wire threaded through the exit slot (2). The handle is then attached and the coil tightly wound onto the bobbin using 13.5 turns of 1.25mm-diameter enamelled copper wire (3). The finished coil (4) is secured using one or two bands of heatshrink tubing around the outside.

The winding jig consists of an M5 x 70mm bolt, two M5 nuts, an M5 flat washer, a piece of scrap PCB material (40 x 50mm approx.) and a scrap piece of timber (140 x 45 x 20mm approx.) for the handle.

In use, the flat washer goes against the head of the bolt, after which a collar is fitted over the bolt to take the bobbin. This collar should have a width that's slightly less than the width (height) of the bobbin and can be wound on using insulation tape.

Wind on sufficient tape so that the bobbin fits snugly over this collar without being too tight.

Next, drill a 5mm hole through the centre of the scrap PCB material, followed by a 1.5mm exit hole about 8mm away that will align with one of the slots in the bobbin. The bobbin can be slipped over the collar, after which the scrap PCB "end cheek" is slipped over the bolt (ie, the bobbin is sandwiched into position between the washer and the scrap PCB).

Align the bobbin so that one of its slots lines up with the exit hole in the end cheek, then install the first nut and secure it tightly. The handle can then be fitted by drilling a 5mm hole through one end, then slipping it over the bolt and installing the second nut.

careful to avoid accidentally shorting to adjacent components.

The inductor goes in next but first you will need to wind it.

Winding the inductor

This is easiest to wind if you make up a winding jig as shown in the accompanying panel. You only need a few cheap and easy-to-obtain items and it will come in handy any time you need to wind a small air-core choke.

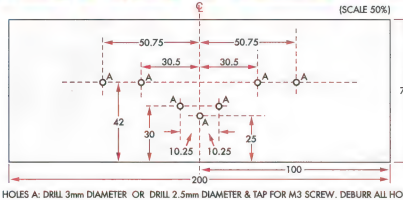
The inductor is wound using a ~1m length of 1.25mm diameter enamelled copper wire on a 10mm wide, 13mm inner diameter plastic bobbin. Fit the bobbin to the jig, or if you don't have a jig, wind some electrical tape around a bolt or dowel so that it is a firm fit through the centre of the bobbin, to prevent the plastic breaking while winding on the copper wire.

For a neat result, the wire can first be straightened by fastening one end in a vice and pulling hard on the other end with a large pair of pliers. This requires a fair bit of strength so be careful in case the pliers or vice let go.

Make a right-angle bend in the wire 25mm from one end, then insert this end through one of the slots in the bobbin and wind on seven closely-packed turns, which should fill the width of the bobbin. Since the winding direction affects performance, we recommend that you wind in the same direction as we did, as shown in the photos.

Once that layer is complete, wind another 6.5 turns on top, again closely-

Drilling & Tapping The Aluminium Heatsink



HOLES A: DRILL 3mm DIAMETER OR DRILL 2.5mm DIAMETER & TAP FOR M3 SCREW. DEBURR ALL HOLES.

Fig.8: this half-size diagram shows the heatsink drilling details. The holes can either be drilled and tapped (using an M3 tap) or can be drilled to 3mm and the transistors mounted using machine screws, nuts & washers.

Fig.8 above shows the heatsink drilling details. If tapping the holes, they should be drilled to 2.5mm diameter **right through the heatsink plate** and then tapped to 3mm. Alternatively, the holes can be drilled through using a 3mm drill and the transistors mounted using screws, nuts and washers.

It's somewhat more work to tap the holes but it makes mounting the transistors quite a bit easier (no nuts required) and gives a neater appearance.

Before drilling the heatsink, you will have to carefully mark out the hole locations using a very sharp pencil. **That done, use a small hand-drill fitted with a 1mm bit to start the location of each hole.** This is important as it will allow you to accurately position the holes (the locations are critical) before stepping up to larger drills in a drill press.

Be sure to use a drill press to drill the holes (there's no way you'll get the holes perfectly perpendicular to the mounting face without one). Use a small pilot drill to begin with (eg, 1.5mm), then carefully step up the drill size to either 2.5mm or 3mm. The holes have to go between the fins so it's vital to accurately position them. In addition, you can drill (and tap) three holes in the base of the heatsink so that it can later be bolted to a chassis.

Be sure to use a suitable lubricant when drilling the holes. Kerosene is the recommended lubricant for aluminium but we found that light machine oil (eg, Singer or 3-in-1) also works well for jobs like this.

Don't try drilling the holes in one go. **When drilling aluminium, it's important to regularly remove the bit from the hole and clear away the metal swarf.** If you don't do this, the aluminium swarf has a nasty habit of jamming the drill bit and breaking it. Re-lubricate the hole and the bit with oil each time before you resume drilling.

Tapping

To tap the holes, you will need an M3 intermediate (or starting) tap (not a finishing tap). The trick here is to take it nice and slowly. **Keep the lubricant up and regularly wind the tap out to clear the metal swarf from the hole. Re-lubricate the tap each time before resuming.**

Do not at any stage apply undue force to the tap. It's easy to break a tap in half if you are heavy-handed and if the break occurs at or below the heatsink's face, you can scratch both the tap and the heatsink (and about $25). Similarly, if you encounter any resistance when undoing the tap from the heatsink, gently rotate it back and forth and let it cut its way back out. In short, don't force it.

Having completed the tapping, deburr all holes using an oversize drill to remove any metal swarf from the mounting surface. The mounting surface must be perfectly smooth to prevent punch-through of the transistor insulating washers.

Finally, the heatsink should be thoroughly scrubbed cleaned using water and detergent and allowed to dry.

packed and in the same direction, then bend the wire through the opposite slot and cut it off 25mm from the bobbin.

To hold the windings in place, cut a 10mm length of 20mm diameter heatshrink tubing and slip it over the bobbin, then shrink it down gently using a hot-air gun on a low setting. Trim the two protruding wires to exactly 20mm from the base of the bobbin then strip 5mm of the enamel from each end using either emery paper or a hobby knife/scalpel and tin the leads.

To get the specified performance, you must mount the inductor as shown in Fig.6, Fig.9 and the photos. Two slots are provided for a cable tie to hold it in place. Bend its leads down through 90° to fit through the PCB pads, then fit and tighten the cable tie before soldering and trimming the leads. **Note the way we've orientated it; each wire from the PCB runs up to and then under the coil former.**

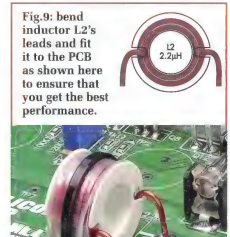
Drilling & tapping the heatsink

If you are upgrading an earlier version of the module, or if you are building this from a kit, you may already have a drilled and/or tapped heatsink. Otherwise, refer to the accompanying panel and the drilling diagram (Fig.8).

Ideally, the seven transistor mounting holes should be tapped with an M3 thread. Take your time doing this since it's quite easy to strip out a hole in aluminium, in which case you may have to start again with a fresh heatsink (or drill the hole right through, as described below).

If you don't want to tap the holes, you can drill all the way through the

Fig.9: bend inductor L2's leads and fit it to the PCB as shown here to ensure that you get the best performance.



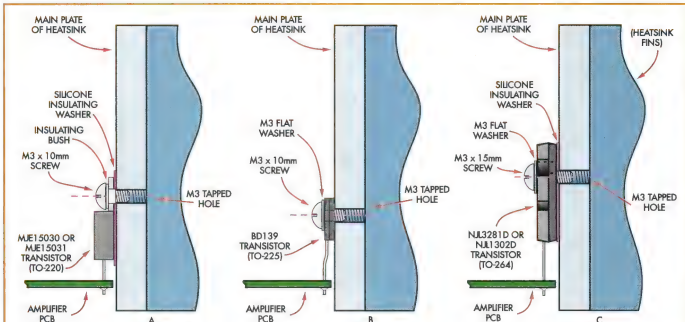


Fig.10: this diagram shows the mounting details for the TO-220 driver transistors (A), the BD139 V_{BE} multiplier (B) and the four output transistors (C). After mounting these transistors, use your multimeter (switched to a low ohms range) to confirm that they are properly isolated from the heatsink – see text for details.

heatsink and use longer machine screws (fed between the fins) and nuts to secure the transistors. However, you must drill the holes with a high degree of accuracy, otherwise the screws may not fit between the fins.

After you have drilled and tapped the transistor mounting holes, you will also want to do something about mounting it in the chassis. Our preferred method is to drill and tap three additional holes along the bottom of the heatsink, as shown in the photo on the following page. However, it's also possible to fit right-angle brackets to the fins at either end of the heatsink. That can be done by drilling right through the fins and using screws and nuts to hold the brackets in place.

Once all holes have been drilled, deburr them using an over-sized drill bit and clean off any aluminium particles or swarf. Check that the areas around the holes are perfectly smooth to avoid the possibility of puncturing any of the insulating washers.

Three M3 or M4 holes can be drilled and tapped in the base of the heatsink so that it can later be attached to a chassis. Make them about 10mm deep.

Fitting the heatsink

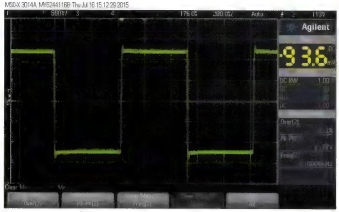
Now it's time to mate the PCB with the heatsink but first re-check the face of the heatsink. All holes must be deburred and it must be perfectly clean and free of any grit or metal swarf.

Start the heatsink assembly by mounting Q7, Q8 & Q9. A silicone rubber washer goes between each of these transistors and the heatsink. Q7 and Q8 also require an insulating bush under each screw head. Fig.10 (A & B) shows the mounting arrangements.

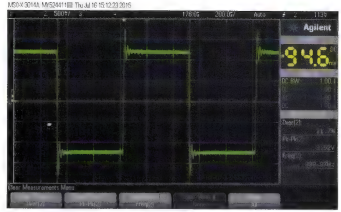
We specified a TO-126/TO-225 insulating washer for Q9 as it is smaller than the TO-220 packages for Q7 & Q8 but if you can't get one of these, you can always cut a TO-220 washer down to size. Just make sure it's still large enough to cover Q9's exposed metal pad completely, taking into account any slop in the screw hole.

Be careful not to get Q7 & Q8 mixed up as their type numbers are similar.

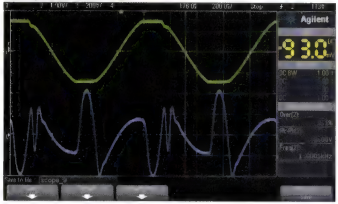
If the holes are tapped, these transistors can be secured using M3 x 10mm machine screws. Alternatively, if you have drilled non-tapped holes, you will need to use M3 x 15mm machine



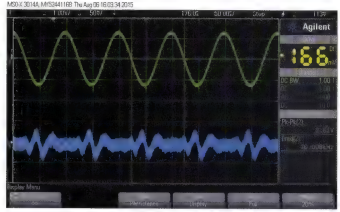
Scope 1: amplifier output for a 1kHz square-wave into a 4-ohm load. As you can see, there is a small amount of overshoot (around 5%) but it recovers quickly with very little ringing.



Scope 2: the same test as Scope1 but with a 2µF capacitor across the load. This results in more overshoot (~20%) and some ringing but it's well under control. This is a standard test for amplifier stability.



Scope 3: here the amplifier is delivering a 1kHz sinewave into an 8-ohm load at around 150W, ie, well into clipping. As shown, negative recovery is quite clean. Positive recovery has a small step due to the high open loop gain but it resumes its normal slope after about 25µs with only a small amount of ringing.



Scope 4: distortion residual at 100W into 8Ω at 10kHz. The distortion level is so low that a significant fraction is noise even at this power level and frequency as shown by the display persistence. The distortion mainly occurs around the negative-most part of the waveform, hence it is even less significant at lower power levels.

screws, with the screws coming through from the heatsink side (ie, the screw heads go between the heatsink fins).

Make sure the three transistors and their insulators are properly vertical, then do the screws all the way up but don't tighten them yet; ie, you should still just be able to rotate the transistors in each direction.

The next step is to fit an M3 x 9mm (or 10mm) tapped spacer to each corner mounting hole on the PCB. Secure these using M3 x 6mm machine screws. Once they're on, sit the board down on the spacers and lower the heatsink so that the transistor leads pass through their corresponding PCB pads. Note that you'll probably have to bend Q9's leads away from the heatsink as shown in Fig.10.

Installing the output transistors

The four output transistors (Q10-Q13) can now be fitted. Two different types are used so be careful not to mix them up (check the layout diagram). As shown in Fig.10(C), these devices must also be insulated from the heatsink using silicone insulating washers.

Start by fitting Q10. The procedure here is to first push its leads into the PCB mounting holes, then lean the device back and partially feed through an M3 x 15mm mounting screw with a flat washer (or M3 x 20mm for untapped holes). That done, hang the insulating washer off the end of the screw and then loosely screw the assembly to the heatsink.

The remaining three devices are then installed in exactly the same way but take care to fit the correct transistor type at each location. Once they're in, push the board down so that all four spacers (and the heatsink) are in contact with the benchtop. This automatically adjusts the transistor lead lengths and ensures that the bottom of the PCB sits 9-10mm above the bottom edge of the heatsink.

Now adjust the PCB assembly horizontally so that each side is 32.5mm in from its adjacent heatsink end. Once you are sure it is properly positioned, tighten all the transistor screws just enough so that they are held in place while keeping the insulating washers correctly aligned.

The next step is to lightly solder the outside leads of Q10 & Q13 to their pads on the top of the board. The assembly is then turned upside down so that the heatsink transistor leads can be soldered.

Before soldering the leads though, it's important to prop the front edge of the board up so that the PCB is at right-angles to the heatsink. If you don't do this, it will sag un-

Improving The Distortion & Stability

Our first prototype of the Ultra-LD Mk.4 incorporated a number of changes which we expected would lower distortion compared to the previous version. For example, the improved magnetic cancellation of the new PCB layout, the non-inductive surface-mount emitter resistors and the greater open loop gain provided by the new transistors should have each provided benefits. So we were disappointed to find that the distortion levels were initially very similar to the Mk.3 version.

Convinced that it should perform significantly better, we investigated what might be holding the performance back. We made a number of interesting and important discoveries during this process. One was that using different load resistors affected the distortion measurements significantly, especially at higher frequencies.

The output inductor's impedance rises with frequency and it forms a voltage divider with the load. With a purely resistive load, this will only cause a roll-off in the frequency response. But if the load has any non-linearities, it will create distortion across the load even if the signal from the amplifier is perfectly clean.

We use the Dummy Load Box described in our August 1992 issue for testing amplifiers and were assuming it was linear on the basis that it had given good results to date. But when we fed a 14V RMS signal from the Audio Precision System Two's ultra-low distortion generator into one end of the load box and connected a polypropylene capacitor from the other end to signal ground, forming a low-pass filter, we found this wasn't the case.

Doing this test with a resistor we thought would be very linear (a 5W wirewound type) gave 0.00025% THD+N at 10kHz with an 80kHz measurement bandwidth. However, using our load box as the resistor gave a higher reading of around 0.0008%, ie, three times higher. Thus it's likely the load box itself was contributing to the higher distortion reading from the amplifier.

To determine the cause, we soldered a couple of wires directly across the resistor banks in the load box and repeated the test. The reading dropped to 0.00025%. We therefore believe the problem is in either the connectors or the relay switching arrangement in the load box. So we had to continue testing using the soldered connections as this was the only way we could find to get a true reading of the amplifier's performance (we will need to further investigate the source of the distortion in the load box at a later date).

Tweaking the output filter

We then measured the amplifier at around 0.0015% THD+N at 10kHz, a slight improvement on the Ultra-LD Mk.3 module under the same conditions (at around 0.002%). But we felt the new module should be more of an improvement than this and subsequently discovered that if we measured the distortion before the output filter, it was dramatically lower, at around 0.0008% @ 10kHz.

Since the filter was still in-circuit and the load current was still flowing through inductor L2, this meant it wasn't due to any interaction between the output filter and the front end. So it had to come down to the output filter itself; either the capacitor or SMD resistors were not linear enough or there was something odd happening to the signal in the inductor.

We then separately tested a number of different resistors and capacitors, using a similar method as before, ie, hooking them up as RC filters and using the Audio Precision gear to test the performance. This gave the SMD resistors a clean bill of health as the four in parallel performed just as well as a 6.8Ω wirewound resistor.

But the X2 polypropylene capacitor we were using on that prototype gave distortion of around 0.0006% in this test. We tested three other polypropylene capacitors, two other X2 types and an MKP. The MKP and one of the X2 capacitors got a clean bill of health (ie, reading around 0.00025%) while one of the other X2s also gave higher than expected distortion. We therefore put the better capacitor on the board but this only made a tiny improvement to its performance.

Having essentially ruled out the capacitor and resistor as being the problem, suspicion fell on the inductor. But was it also possible that the connection routing on our PCB was not 100% correct, especially in the earth tracks? To rule this out, we removed the RLC filter from the PCB and mounted it

der its own weight and will remain in this condition after the leads have been soldered.

A couple of cardboard cylinders cut to 63mm can be used as supports (eg, one at each corner adjacent to CON1 & CON3). With these in place, check that the board is correctly centred on the heatsink, then solder all 29 leads. Make sure the joints are good since some can carry many amps at full power.

Once the soldering is completed, trim the leads using a steel rule as a straight edge to ensure consistent lead lengths. That done, turn the board right way up again and tighten the transistor mounting screws to ensure good thermal coupling between the devices and the heatsink.

Don't over-tighten the mounting screws though. **Remember that the heatsink is made from aluminium, so you could strip the threads if you are too ham-fisted.**

Checking device isolation

You must now check that the transistors are all electrically isolated from the heatsink. That's done by switching your multimeter to a high ohms range and checking for shorts between the heatsink mounting surface and the collectors of the heatsink transistors (note: the collector of each device is connected to its metal face or tab).

For transistors Q7-Q8 and Q10-Q13, it's simply a matter of checking between each of the fuse-clips closest to the heatsink and the heatsink itself (ie, on each side of the amplifier). That's because the device collectors in each half of the output stage are connected together and run to their respective fuses.

Transistor Q9 (the V_{BE} multiplier) is different. In this case, you have to check for shorts between its centre

entirely off-board, between the output connector and test load.

This completely solved the problem, giving the excellent performance indicated in the Audio Precision plots last month. But why? We moved the inductor and resistors back onto the PCB but left the connections the same and the measured distortion doubled again. This pretty much ruled out a routing problem. So we mounted the inductor on short lengths of flexible wire and experimented with changing its position and orientation.

Both the position and orientation of the inductor affected performance, however the mounting location mattered a lot less with the inductor rotated to rest on its side. Presumably this is due to its magnetic field affecting a plane orthogonal to the tracks on the PCB. And this is how we ended up with the final mounting arrangement.

The only reason we can figure that this matters is that high-current pulses in the PCB power supply tracks were being picked up by the inductor and injecting a distortion signal into the load. This effect is greater at higher frequencies because the inductor's higher impedance with these signals more effectively isolates the loudspeaker output from the low-impedance junction of the output transistor emitter resistors.

By the way, we're fairly sure that this amplifier has lower distortion than the 20W Class-A amplifier published in the May-September 2007 issues. The main advantage of a Class-A amplifier compared to a Class-B or Class-AB is that it doesn't have any crossover distortion since all the output transistors are conducting all the time. Well, if this new Ultra-LD design has any crossover distortion, we certainly can't detect it!

In fact, if you make direct comparisons between the distortion curves in the July 2011 issue with those published last month (August 2015) you will see that the Ultra-LD Mk4 is a dramatic improvement on the previous design. Is there likely to be an audible difference? We think that is highly unlikely!

We suspect what little distortion remains is mostly due to non-linearities in the front end – which a Class-A amplifier would suffer from equally. The bottom line is, there isn't really any point in building a Class-A amplifier any more. You might as well build this one and get much more power, higher efficiency and less heat dissipation.

Stability improvements

While tweaking the amplifier's performance, we changed some components which compromised stability and occasionally triggered oscillation, although no damage occurred as a result. This did, however, allow us to discover some ways to improve overall stability.

This happened almost by accident. What we found was that when the amplifier was in an unstable condition and started to oscillate, touching certain components on the PCB would cause the oscillation to temporarily cease.

We isolated this effect to two specific components: Q4's collector resistor and the 2.2kΩ resistor from the junction of the two 150pF capacitors to the negative rail (part of the compensation network around Q4/Q6). We figured that connecting capacitors across these resistors would have a similar effect on stability to touching them with a finger and proved this by modifying the prototype in this manner and curing the oscillation entirely.

We explained the reason for the first of these two improvements in Pt.1: it eliminates the Early effect on Q4 which causes a form of local feedback. This change alone appears to make the amplifier much more tolerant and allows reduced compensation without prejudicing high-frequency stability.

The advantage of the 15pF capacitor in the compensation network is less clear. Simulation suggests that it slightly reduces the phase shift around the VAS at very high frequencies while having a negligible effect on gain. But the combined effect of these two changes appears to be that if the amplifier does "misbehave", it's far less likely to go into damaging high-frequency oscillation.

By the way, we tested all of the circuit changes in SPICE simulations to check that they were sensible but ultimately had to try them all on the prototype to verify their effect on performance and stability. Simulation is a good way of quickly finding out if a change is a bad idea without blowing the amplifier up, but when simulation shows that something should work, it's far from certain that it actually will.

One area in which simulation excels is the ability to see what's going on in the circuit. For example, you can easily display the current passing through any component in the circuit whereas doing this on the real prototype would involve de-soldering the component and inserting a shunt which might upset the circuit's operation.

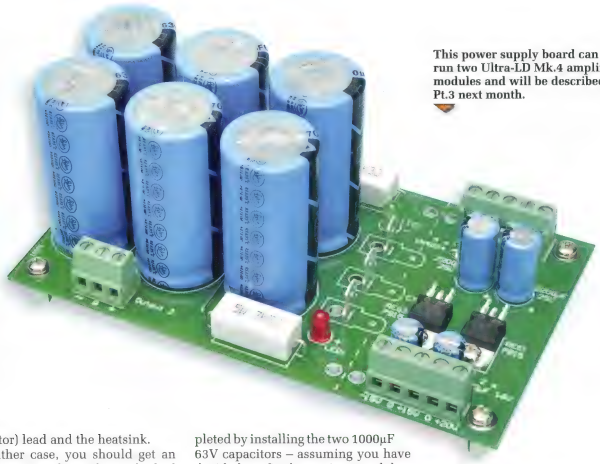
Thin Film SMD Resistor Values

You may have noticed in the parts list published last month that we specified some odd value resistors. For example, 6.49kΩ, 332Ω, 47.5Ω and so on. As we explained then, many of the resistors in the circuit must be thin film types for good performance (many SMD resistors have thick film construction which is not suitable).

The best SMD thin film resistors we found are made by a company called Stackpole Electronics. Besides being thin film, they also have a relatively high wattage rating for their size (3.2 x 1.6mm) of 0.5W. However, this series of resistors (RNCP1206FTD) comes in the E96 series of values rather than the E24 series we are used to.

The E24 series is as follows: 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91. It then repeats scaled up (or down) by a factor of 10. In other words, within every 10:1 ratio of resistances, there are 24 values to choose from and each value is roughly 10% higher than the next one down.

As you may have guessed, the E96 series has 96 different values for each decade. But while the E24 series contains all the values of the E12 series and simply adds new values in-between, the E96 series does not contain all the E24 series values. So the RNCP1206FTD series of resistors does not offer 6.2kΩ, 330Ω or 47Ω. In practice this does not matter as we simply picked close values (this circuit will tolerate values a few percent higher or lower, as long as all resistors of the same nominal value are closely matched.



This power supply board can run two Ultra-LD Mk.4 amplifier modules and will be described in Pt.3 next month.

(collector) lead and the heatsink.

In either case, you should get an open-circuit reading. If you do find a short, undo each transistor mounting screw in turn until the short disappears. It's then simply a matter of locating the cause of the problem and remounting the offending transistor.

Be sure to replace the insulating washer if it has been damaged in any way (eg, punched through).

Completing the assembly

The PCB assembly can now be completed by installing the two 1000µF 63V capacitors – assuming you have decided to fit these. As stated last month, they can be left out as long as the power supply leads are kept short and made from thick wire. Otherwise the maximum output power will drop a little bit, due to losses in these cables, but performance should not be affected.

This view shows the mounting details for the V_{BE} multiplier transistor (Q9) and the two driver transistors (Q7 & Q8). Check that these transistors and the four output transistors (Q10-Q13) are all isolated from the heatsink

One of the changes we've made in designing this PCB was to place these capacitors so they don't interfere with access to the heatsink mounting screws to the same extent as they did on the Mk.2 and Mk.3 versions. However, working on the PCB is still easier if the large capacitors are not fitted and due to their proximity to the heatsink, they will probably dry out eventually (albeit probably after more than 10,000 hours of use, assuming they are good-quality capacitors).

Now remove the two support spacers from the edge of the board adjacent to the heatsink. In fact, it's quite important that the rear edge of the board be supported only by the heatsink transistor leads. This avoids the risk of eventually cracking the PCB tracks and pads around the heatsink transistors due to thermal expansion and contraction of their leads as they heat up and cool down.

In short, the rear spacers are installed only while you fit the heatsink transistors and must then be removed. They play no part in securing the module. Instead, this edge of the module is secured by bolting the heatsink itself to the chassis.

As previously stated, this can be done by tapping M3 (or M4) holes into the main plate on the underside of the heatsink or by using right-angle brackets. The front of the board is secured using the two M3 x 9mm (or 10mm) spacers fitted earlier.

Power supply & speaker protection modules

That completes the assembly of the power amplifier module. The next step is to build the power supply module (shown in the above photo) and we'll describe how that's done next month. We'll also explain how to power up and test the amplifier and give some basic details on housing it in a metal case.

Finally, we'll present the revised speaker protector module, which can also monitor heatsink temperature. You will need it (or our previous design) to prevent an amplifier fault from destroying the speakers and potentially causing a fire. SC

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Vintage Radio

By Ian Batty

The unique GE 675 5-transistor radio

First marketed in 1955, GE's 675 radio uses just five transistors. It features a class-A audio output stage, has unusual AGC and volume control circuits, and is powered from a 13.5V/4.5V battery.

THOMAS EDISON began inventing at an early age but burst onto the public stage in 1877 with his invention of the phonograph. His wide-ranging interests led one author to subtitle an Edison biography as "Inventing the Century".

By 1889, Edison's output was spread over many technology companies and these were eventually consolidated into the Edison Electric Light Company. The Thomson-Houston Electric Company, a major Edison competitor, was amalgamated with Edison's holdings in 1892 to become General Electric.

Now a multinational giant, GE was one of just 12 companies that listed on the newly-formed Dow Jones Industrial Average in 1896. It's now the only one of those original 12 still listed today. As an aside, in 1919 Owen D. Young founded the Radio Corporation of America (RCA) as the retail arm of GE. RCA was subsequently spun off as an independent business in 1930.

In common with several other electronics manufacturers during World War 2, GE worked on microwave diodes for use in radar receiver mixers. The company's eventual entry into transistor manufacturing began when Albert Hull, an electrical engineer with GE, read about Bell Labs' development of the transistor and decided that GE's extensive diode work gave them the necessary expertise in that field.

GE's 675

The GE 675 is a 5-transistor set with a class-A audio output stage. Depending on when it was made, it uses either a diode demodulator or a class-B demodulator/first audio stage. It also uses an ingenious "sliding bias" volume control/bias circuit for the output stage.

A 5-transistor design may seem like a recipe for poor performance but it's worth noting that a conventional 6-transistor set has only five amplifying stages. That's because two of its six transistors are used in a push-pull audio output stage.

GE's 675 follows the style established by Regency's TR-1 (see SILICON CHIP, April 2013). It's a stark, minimalist design and like the TR-1, it uses thumbwheel tuning but has a front-operated volume/on-off control. It's also similar in size to the TR-1; ie, it fits into a coat pocket rather than a shirt pocket.

The set shown here came in its original leather case. Like the Philco T7, this case opens part way at one end to allow tuning and volume adjustments without completely removing the set. My GE 675 has a black cabinet but on-line catalogs show that it was also available in ebony, ivory, red and aqua.

The 675 is a later design than the TR-1 and has more audio output, as described below. It uses an air-spaced tuning gang with a smaller (cut-plate) oscillator section and as such, has a tendency to cramp the stations close together at the top end of the broadcast band.

Circuit details

Fig.1 shows the circuit details of the GE 675. It's a fairly straightforward superhet design using four PNP transistors (X1-X3 & X5) and one NPN transistor (X4).

Converter stage X1 is conventional, with collector-base feedback via oscillator coil T2. This stage feeds the tuned, untapped primary of the first IF transformer (T3) and its untapped secondary in turn is coupled to the first IF amplifier stage (X2).

On my set, X2 is neutralised using

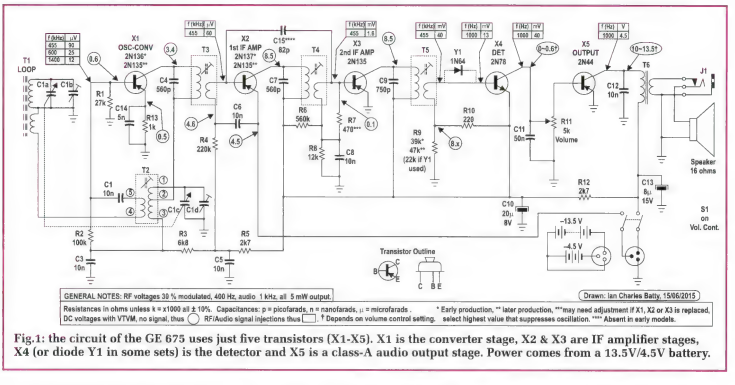


Fig.1: the circuit of the GE 675 uses just five transistors (X1-X5). X1 is the converter stage, X2 & X3 are IF amplifier stages, X4 (or diode Y1 in some sets) is the detector and X5 is a class-A audio output stage. Power comes from a 13.5V/4.5V battery.

C15. As shown, this capacitor is connected between X2's base and the secondary of the second IF transformer (T4). However, earlier circuits do not show this, which meant that early sets worked without neutralisation of any kind. This helps explain: (a) the double-sided PCB used with an extra ground plane (very unusual in domestic radios), (b) the copper shield covering the set's entire component side and (c) the small ferrite rod mounted above the copper shield. All three methods are commonly used to improve shielding and reduce feedback.

An unusual design feature is that X2's emitter is connected to a 4.5V tap on the special 13.5V battery that's used in this set. Since X2 uses simple series bias from the main supply via resistor R4, this is an odd circuit configuration. There is no DC feedback from the demodulator, so this radio appears to lack AGC. However, this unusual circuit is, in fact, the AGC section (see later).

It looks rather like the configuration used in some valve sets that applied AGC to the converter alone. This allowed the IF amplifier to draw grid current (via a high-value grid resistor) on strong signals and to slide its bias, thereby reducing the gain.

The first IF amplifier (X2) feeds the untapped, tuned primary of the second IF transformer (T4). Its untapped secondary then feeds the second IF amplifier stage based on transistor X3.

As usual, this stage works with fixed bias but without neutralisation. A brave move? Well, there's R7 which is used as a damping resistor across T4's secondary. If transistors X1, X2 or X3 are replaced, then R7 may need to be adjusted to prevent oscillation (its maximum value is 500Ω). However, while this damping effect obviously prevents oscillation by reducing gain, adding neutralisation to the second IF amplifier stage would have given more gain and eliminated the need to adjust R7.

The Sams Photofact website (https://www.samswebsite.com/) states that demodulator diode Y1 was "used in late productions only". Without it, transistor X4 is biased so that it functions as a class-B demodulator, although in practice, it provides both demodulation and audio gain.

The amount of bias is quite small: just enough to bias the base into conduction while eliminating the incoming IF signal's negative peaks. Conversely, the positive peaks are amplified and then filtered by C11 to recover the audio signal (the circuit works similarly with Y1 in place).

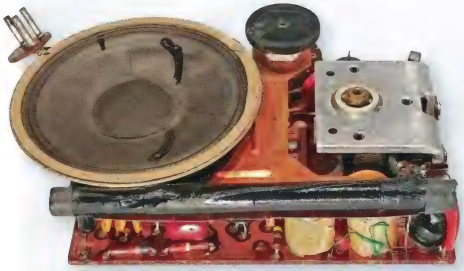
Volume potentiometer R11 forms the DC and AC collector load for X4. The way in which this pot has been wired is rather unusual. As shown, X4's collector goes to the pot's wiper and so X4's load resistance (and thus the stage gain) varies with the volume setting. Even more strangely, the top of the pot is connected to the base of output stage transistor X5.

X5 has no constant bias source. Instead, it's effectively biased due to X4's collector current flowing through R11 and that bias is modified by the volume control setting.

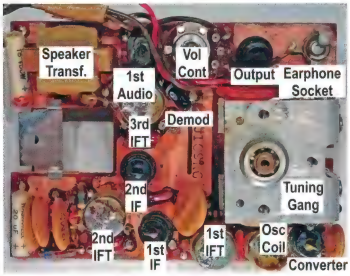
So what we have is a sliding bias circuit. At low volume settings, X5's bias is reduced but that doesn't matter as it doesn't need much collector current to reproduce a low-level audio signal accurately. Conversely, at higher volume settings, X5's bias is increased to allow higher output power without undue distortion.

Given the power-hungry nature of class-A stages generally, it's an elegant solution to the problem. In the absence of any signal, X5's collector current varies from about 2mA at the minimum volume setting to 3mA at the maximum setting. But X5's collector current also responds to signal strength since its bias is controlled by X4's collector current. Strong signals increase X4's collector current and this pushes X5's collector current up as well, to as much as 25-30mA.

In most sets, it's common to monitor signal strength by the drop in the first IF amplifier's collector current due to AGC action. By contrast, the 675 responds to stronger signals by increasing its output stage's collector current and I monitor either this or X2's emitter



The GE 675 is built on a small double-sided PCB, with the ferrite rod antenna mounted along one side.



This view shows the main parts side of the PCB, with the major components marked. Note the comparatively large tuning gang.

current during alignment and testing.

Given the elegance of this part of the circuit, it's puzzling as to why they didn't follow common practice and use neutralisation in the second IF amplifier stage to make the set stable. In addition, given that the 2N44 output transistor (X5) is rated at 250mW maximum dissipation and there's no thermal stabilisation, I'd be wary of running this set at full volume on strong stations for any length of time.

Restoration

As it came to me, my GE 675 was completely dead. Any five or 6-transistor radio should give some converter noise at full volume or, at least for an old set, would have a noisy (scratchy) volume control pot.

The power switch was an obvious suspect so I checked this first. It was open circuit regardless of position and since it was soldered to the PCB, I temporarily bridged it out with some short wires. My intention at this stage was simply to get the set going and to replace the switch later.

The set was still dead and further checking revealed that the earphone socket had gone open circuit due to dirty contacts. A light polish with some wet-and-dry paper fixed that problem.

I then tried injecting 455kHz into the front-end but the set produced virtually nothing. A close inspection of the PCB revealed the probable cause – the IF transformer slugs had all been adjusted right to the top of their travel. By swinging the signal generator's frequency up and down, I quickly found a response at some 500kHz-plus. A quick check of the Sams Photofact circuit confirmed that the IF should, in fact, be 455kHz.

As a result, I adjusted the IF coils and I could then hear some noise when a 455kHz signal was radiated in from my test loop. However, there was still no broadcast-band reception. So was the 675's local oscillator working correctly? I placed another AM radio nearby, tuned it to 1600kHz and swung the 675's tuning dial in either direction but to no effect.

In practice, there should have been a whistle from the other set as the 675's local oscillator swung through 1600kHz, so this oscillator clearly wasn't working. A subsequent close examination of the circuitry revealed that the lead from the top of the oscillator coil to the tuning gang had gone open circuit.

Repairing this open circuit resulted in broadcast-band reception at last. By the way, if you ever work on one of these sets, be aware that the flying leads from the various coils to the PCB consist of very fine wire. This means that you have to be very careful not to break them when working on the set.

Low sensitivity

Although the set was now working, its sensitivity was quite low, so it still had a fault somewhere. However, I already has a good idea as to what the problem was – some heavy-handed person had damaged the second IF transformer so badly that I was unable to tune its slug back out to its desired position. My guess is that someone had adjusted the IF slugs to their extreme positions in an attempt to get the set going, not realising that the fault was actually in the local oscillator.

At this stage, I decided to take a look at a second GE 675 set I'd obtained. This had an open-circuit track to the output transformer and its ferrite rod had also come loose, resulting in broken leads. Once these problems had been fixed, the set began working and after alignment, it performed quite well.

Apart from that, the set only required a quick clean-up. The cabinet was given a polish, while a wipe-over with leather preserver soon had the case looking almost as good as new.

Performance

So just how well does it perform? First, its output at clipping was only

about 35mW but even at this low level, the output stage current drain increases noticeably. The GE Transistor Manual, 2nd Edition (pages 99-105), shows several circuits with class-A output stages. Each of these quotes a significantly higher output of 75mW, while their sensitivity figures are specified at an output of just 5mW (which I've used for testing).

The circuit diagram shown in Fig.1 is a composite of several online examples. The component numbering follows the circuit in Beitmans "Most-Often Needed 1956 Radio Servicing Information" Volume R-16, which is more detailed than the Howard W. Sams Photofact. The Beitman circuit also includes coil resistances but omits the transistor resistance measurements in the H. W. Sams document

Be aware also that the Beitman circuit recommends using a 20kΩ/V meter for voltage measurements. However, a 20kΩ/V meter gives a misleading low measurement of just -3.5V on the base of the first IF amplifier (X2).

In addition, the Sams circuit shows only one voltage for the output transistor's collector (X5) while the Beitman circuit shows the expected range according to the volume control setting. The Beitman and Sams circuits are both available on Ernst Erb's website (see listing at the end of this article).

How does it compare?

The GE 675 is just a little bigger than Regency's TR-1 but its greater output power is noticeable. And because there are no coupling capacitors in the signal path, its audio response is controlled by the IF-stage bandwidth and the output transformer (T6). In fact, the frequency response from antenna to speaker is 160Hz to about 4.3kHz which is quite good for this type of set.

The IF selectivity is -3dB at ±6kHz and -60dB at ±65kHz. The audio performance is adequate: at 5mW output, the THD (total harmonic distortion) is around 6% at 1kHz, while at 30mW it rises to around 8%. As stated above, it begins to clip at 35mW output.

The RF sensitivity at converter X1's base is about what you'd expect: 25μV for 5mW output at 600kHz and around 12μV for 5mW at 1400kHz. Due to its low-gain IF stages, it achieves this for a signal-to-noise ratio of about 18dB. By contrast, the Philco T7 has a sensitivity of about 50-80μV respectively for a 50mW output.

The leather case opens at one end to allow tuning & volume adjustments without completely removing the set.

In practice, the GE 675 provides an output of 5mW for a field strength of 750μV/m at 1400kHz and struggles to better 2mV/m for 5mW at 600kHz. The small ferrite rod is probably the cause of this problem, as the set's sensitivity is quite acceptable when signal is directly applied to X1's base.

What about AGC? Despite there being no feedback from the detector to control IF amplifier X2's bias (and thus its gain), its emitter current does in fact fall with increasing signal. This results in the output rising just 6dB for a signal increase of around 25dB.

So how does the AGC work? The answer involves 220kΩ resistor R4 which provides a bias current of about 40μA to transistor X2. As the IF signal on X2's base increases to several millivolts, X2's base-emitter junction (which is already forward-biased) begins to act as a rectifier. The resulting current effectively opposes the 40μA bias current supplied via R4, thereby reducing X2's collector current and its gain.

In operation, X2's collector/emitter current falls proportionally according to increases in signal strength. In fact, it behaves just like a more conventional gain-controlled stage.

As mentioned earlier, a similar scheme was used in some valve radios, with a grid-leak circuit providing gain reduction on strong signals.

Would I buy any more?

Although this set's design is rather unusual, it's not a remarkable performer. Nor has it the eye-catching design of (say) the Philco T7. I'm still puzzled by its poor performance and it's possible that some obscure fault still exists that I've yet to track down.

I also think that this was a rushed design. In practice, transistor production spreads could have been handled by selecting neutralising components to match individual transistors. Although this is time-consuming and adds to the cost, it's exactly what Regency did with their TR-1 and something that GE could have adopted. If my measurements are accurate, this set's RF/IF design badly lets it down.

That said, the GE 675 is worth having as an example of early transistor radio engineering. If you are interested in obtaining one of these unique sets, they're often available online at low cost.

Finally, it's worth noting that the GE 657-678 models are all similar apart from a few component changes.

Further reading

(1) Thanks to Mark P. D. Burgess for his outstanding site at https://sites.google.com/site/transistorhistory/Home/us-semiconductor-manufacturers/general-electric-history

(2)The GE Transistor Manual is at: http://n4trb.com/AmateurRadio/SemiconductorHistory/GE_Transistor_Manual_2nd_Edition.pdf

(3) Thanks to Ernst Erb for his Radio Museum's listing of circuits and other information on the GE 675 at http://www.radiomuseum.org/r/general_el_675.html

A discussion page is at: http://antiqueradios.com/forums/viewtopic.php?f=4&t=208340 SC

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Replacing a halogen lamp in a flasher circuit

I am building the Really Bright Flasher project (Jaycar Cat. KJ-5089) which has a variable flash rate of 0.5s to 3.5 seconds and the kit comes with a 12V halogen lamp. The instructions explain that because of the thermal lag of a halogen lamp, a quicker on and off time is not possible.

Since the kit was first designed, 12V automotive LEDs are now readily available without thermal lag. Being a novice, what components would I need to change to speed the flash rate to, say, 0.1s to 0.5s or even for it to be a mini strobe light? (R. W., via email).

● You can speed up the flash rate by changing the value of the 47µF capacitor that connects to 555 timer IC1 at pins 2 & 6. That capacitor is located just below diode D2 on the PCB.

A 10µF capacitor will provide a nominal 0.1s to 0.75s rate adjustable with trimpot VR1. If you want a faster flash rate, reduce the capacitor even more.

Problem with video to USB converter

I realise that you are not obliged to give advice on items or matters not related to your projects, however you may have experienced this problem or maybe one of your readers has. I purchased an Easycap Video to USB converter; at $10, a bargain or so I thought. The "exe" file files that come on the supplied disc do not make the computer go into install wizard mode.

I am using a laptop running Windows 7, 64-bit. Instead, when I click on one of the "exe" files it opens in record mode and I can record from a DVD player to my computer. The files play back perfectly but no sound is forthcoming.

I have tried setting the USB mic as the default and can hear the sound to be recorded in listen mode but it still won't record sound. I also tried coupling the sound in via the mic input jack and setting this as the default but still no joy.

According to Google searches, it is a very common problem but after trying many of the suggested fixes and software downloads I am getting nowhere. The eBay seller does not seem interested in replying to emails and it is not worth sending it back for $10. So I am just wondering if anyone has a fix for this otherwise handy device.

● We do not have any experience with this device. Perhaps one of our readers has the cure.

Ultrasonic anti-fouling for sandwich hulls

I am a boat designer and I note that your ultrasonic anti-fouling project (SILICON CHIP, September & November

Amplifiers Must Be Fitted With Output Inductors

I've just built the SILICON CHIP Tiny Tim 10W + 10W amplifier (SILICON CHIP, October & December 2013, January 2014). It's working but I have observed that the output level is quite low and the BD139/BD140 transistors get very hot to the touch. In fact, I've bolted on some improvised heatsinks made from offcuts of aluminium just for the time-being.

I haven't received delivery of the inductor bobbins as yet, so in my impatience I've powered it up without the inductors in place. The amplifier works OK and has been powered up for periods of over 10 minutes, with no smoke, no audible distortion or other unwanted artefacts (other than the output transistors getting hot!).

However, with an analog line in from a CD player connected to the input, the output level into 4-ohm speakers (or with headphones plugged in) is not high – even with the volume control set at maximum.

Shorting the 10Ω resistor in the output filter increases the level somewhat but not massively so. Inputs from devices with higher output levels (such as an iPod) fare better though.

● The BD139 & BD140 each dissipate about half a watt so they can be expected to become quite warm but not hot, under normal conditions.

However, your amplifier is not operating under normal conditions. With no inductors the amplifier is highly likely to be oscillating supersonically. No wonder things are getting hot and that's why the output seems weak. You must install the output inductors.

We can understand your frustration in not being able to obtain the bobbins to wind the inductors. Even if you cannot obtain the plastic bobbins, it is relatively easy to wind the necessary turns of enamelled copper wire onto a former made from a 10mm length of 12mm diameter rod with two end cheeks of plastic, wood or metal bolted together. After the choke is wound, the former would be disassembled to remove the choke.

To make sure that the choke does not tend to deform, you could dip it in hot wax; when it cools the wax will hold the turns rigidly.

One other possibility is to wind the inductors on plastic sewing machine bobbins. These have different dimensions to the specified bobbins but they should be readily available from sewing machine retailers and haberdashery shops anywhere around the world. We hope to report on this possibility next month. By the way, do not even think of winding the coils on a metal sewing machine bobbin – that would definitely not work!

2010) does not function on boat hulls which have sandwich construction. From what I understand, the foam prevents the ultrasonic vibrations being transmitted throughout the hull.

So with this kind of construction, do I join the skin interior with the external skin and put monolithic fibreglass on the area where the transducer will be mounted inside the hull (as shown on my attached sketch)? Do you think that your system would function? If so, the manufacturing process is easy and that would increase the sales of your ultrasonic anti-fouling system. (J. F., via email).

● As far as we know, there is really no effective way of using ultrasonic anti-fouling on hulls with sandwich construction. Even if you cut the foam from the transducer mounting, the foam will still be present over the rest of the hull and this will effectively damp any ultrasonic energy from being propagated through the hull.

Classic DAC playback problem

I was doing some testing of various music and audio sources though my Classic DAC (Silicon Chip, February to May 2013) and noticed that when I played the *Lord of the Rings* movie DVD I did not get much or any audio. I also tried *The Sapphires*, with the same result. Is this right? They are recorded with Dolby Digital 5.1 Surround Sound.

Both of these movies have a stereo selection which I tried but this made no difference. The same player works very well with music CDs. Could you please let me know what is or is not working?(P. V., via email).

● It's likely that the stereo audio is being produced in a compressed format. The CLASSiC DAC only supports linear PCM audio data.

Check the set-up menu in your DVD player. Most players have an option to output linear PCM only. It may be called "stereo down-mix" or "LPCM" or something similar. If you select that, then any audio track will be sent to the digital outputs in a format that the CLASSiC DAC will be able to decode.

If the player is producing audio data compressed using Dolby Digital, DTS or a similar scheme, that would require the DAC to contain a decoding and down-mixing engine which needs a software license from Dolby, Digital Theatre Systems and any other patent holders. While possible, it's unclear how to do this legally and it certainly would increase the complexity.

Substitute Mosfet for anti-fouling unit

I have built a 24V version of the ultrasonic anti-fouling unit, following previous suggestions from you. The unit worked well for some months but when I checked a couple of weeks ago the indicator light was out. A further check showed that the fuse had ruptured. As I had little gear on the boat for any further testing I had to remove the electronics and bring it home for further investigation.

On examining the fuse, it was a catastrophic failure. It was not a slow-blow type and there were globs of molten metal within the glass envelope. Further investigation showed that both Mosfets were shorted as well as zener diode ZD2.

A further test with a 500V megger showed that the insulation resistance between the primary and secondary windings of the transformer was in excess of 1000MΩ so that is apparently OK. Can you tell me why the unit failed? Also Radiospares in New Zealand have none of the Mosfets. As this unit worked well I would not like to ditch it. (R. L., via email).

● Testing with a 500V megger could easily damage the surrounding components if the transformer was not tested out of circuit. The transformer could

Choke Problem In 12-Digit Frequency Counter

I have purchased the two PCBs for the 12-Digit Frequency Counter and, after spending some time locating all the parts, I have built it. However there is a problem with the tracks for the ADCH-80 choke on the PCB. You have used pins 3 & 6 but the RFC only has connections to pins 2 & 5, so I had to link them out to get it to work.

The "A" input works fine but the "B" input will just not work. I have fed a signal into the input and used a spectrum analyser to see the signal coming out of the prescaler section from IC4 into Q1 but it will just not display a frequency. Are you aware of any other errors on the PCB before I have to tear the whole thing apart and start again? (M. P., Brighton, UK).

● It seems like you may have been supplied with the ADCH-80+ instead of the ADCH-80A+ specified in the parts list. It has a different pin-out but is otherwise identical.

This can be worked around by simply bridging the pins (2/3 & 5/6). This has happened to a number of people since if you search the Mini-Circuits website for ADCH-80A+, it's the ADCH-80+ which comes up first (very annoying)! The PCB is correct.

We assume that you are switching to Channel B using the front-panel switch and that the associated LED is lighting up. When Channel B is selected, pin 9 of IC13 should go high and pin 5 should go low. This changes which signal is being fed to IC12b. After IC12b, the counter circuitry is common for both channels so assuming the signals from IC4's outputs are correct, that just leaves the differential-to-single-ended circuit using Q1/Q2 and IC13 as being the possible sources of problems.

You need to use a frequency counter which can count up to a few MHz (many DMMs are suitable) to check the signal at pin 8 of IC13 when Channel B is selected. It should be 1/1000th the frequency of what's being fed into the Channel B input.

If that's no good, look for the signal at pin 9 of IC13. If it's there, then there's a problem with the control logic; if not, then we would be suspicious of Q1/Q2. Check that these are the right type, installed correctly and possibly try replacing them as one may be faulty.

Ideally you should use a scope to check that the differential signals from pins 6 & 7 of IC4 are in antiphase and of the correct amplitude and frequency. If the signal from Q1's collector is still no good after checking/replacing Q1 and Q2 then there's something wrong with the Channel B divider chain but it's hard to say where exactly without a scope. If you cannot get access to a suitable oscilloscope, have a very good look at all the SMD components, especially their orientations and soldering.

More Power Wanted From The Currawong Valve Amplifier

I have seen the Currawong amplifier and have even bought the PCB and rare component set, planning to build the amplifier in the near future. However, I have one point of mild criticism and a question.

I have almost assembled a simple valve amplifier based on 6L6s and I am aiming for an output power of 20-25W. How come the power of Currawong is so limited? I get it that the proposed transformers have limited it to some 10-15W but will heavier transformers give more power or do I have to make other changes as well?

What I have in mind is either an Edcore (www.edcorusa.com/cxpp25-8-6_6k) or a British unit (http://livinginthepast-audioweb.co.uk/index.php?p=xfrmrvt11264 or http://livinginthepast-audioweb.co.uk/index.php?p=xfrmrvt1425) I would also consider buying transformers from Hong Kong (www.vt4c.com).

I really need to read the articles thoroughly but it would be unlike me if I did that before asking my questions. There are a lot of 6L6 variations: KT66, 5881, EL37, even 807 and EL34, not to mention Russian 6P3S. Of the latter, I have four 6P3S-E and wonder if they could fit (electrically) in the Currawong – see www.tubes.ru/techinfo/HiFiAudio/6p3s.html (M. K., Vanesburg, Sweden).

- Two factors limit the power output: the power supply and the output transformers. We could have obtained quite a bit more power with a bigger power supply but it would have been a lot more expensive because we would not have been able to use cheap and readily available transformers etc. And then we would have also needed to use bigger output transformers which would have increased the cost even more.

In fact, to get, say, 30W per channel could have easily doubled the overall cost of an amplifier which even now is quite expensive.

By the way, did you read the follow-up article on using more expensive output transformers in the Currawong, in the March 2015 issue? The overall conclusion of that article was that the greatly increased cost was simply not justified.

still be defective, in spite of your insulation test. Possibly either the primary windings in the transformer have shorted, the 5V supply has failed or IC1 has failed. The shorted zener diode may have just been the result of the Mosfet failure. That may mean that IC1 is also damaged so IC1's operation must be checked before installing new Mosfets.

To replace the Mosfet, You could use the IRLIZ44GPBF N-channel logic-level Mosfet, Radiospares No. 813-0711, manufactured by Vishay.

Balance control wanted for headphone amplifier

Remember in the early days of transistors when the h_{fe} spread of transistors was considerable and most hifi amplifiers had a balance control?

I invited one of my neighbours to listen to my stereo headphone amplifier (Silicon Chip, September & October 2011). I had just started the demonstration when she said it was much louder in her right ear although she hadn't noticed this when listening to her TV. She has since found out that her hearing is down in her left ear; nothing wrong with my ears though.

So would it be possible to incorporate a balance control into a modified amplifier, as this is very noticeable with headphones and not so much with speakers? (D. S., via email).

- That's a fair question. There is a way in which a single potentiometer could be incorporated into the circuit to provide a limited range of balance control but it would be difficult to avoid prejudicing the performance, particularly separation between channels and possibly distortion. However, a more difficult problem would be to fit an extra control into the already tight case.

Modification for battery voltage regulator

I have a spare Jaycar KA1795 Add-on Regulator kit that was originally published in the July 1997 issue of *Electronics Australia*. I have a need for a low-power 24V charger, 1-2A, that I can leave unattended and this kit is spare. Is it possible to modify it for operation with a 24V battery or can you suggest another option?

I have used this kit on a 12V charger and I built it with a 25A SCR. It has served well for many years. (M. R., via email).

- Increase the value of R6 to 2.2kΩ or 2.7kΩ so that you can adjust trimpot VR1 for a cut-off of about 28V.

Audible indicator wanted for sensor light

I have several Clipsal outdoor motion sensors (www.agmelectrical.com.au/buy-led-lighting-en/sensors/clipsal-infrascan-10a-3-wire-outdoor-sensor-ip66-750wpr.html) around the house and there is one that I'd like to monitor with an audible beep as it's at the opposite side of the house.

I was wondering if Silicon Chip has ever published a project that produces one or two short audible beeps with an "on" LED indicator, whenever the circuit is powered by 230VAC? This circuit could then be switched by the PIR sensor. (C. K., via email).

- We haven't done anything like this specifically. Perhaps a 12V DC plugpack could be used as the power supply when mains is switched on. In other words, the 12V DC plugpack is powered on via the motion sensor when it detects movement.

A standard 12V doorbell could be used to provide the warning sound when it is powered up (with the doorbell switch wired closed). Or you could build the Jaycar Ding Dong Doorbell from *Short Circuits 3* (Jaycar Cat KJ8052).

Tacho problem with programmable ignition

I have just completed the Programmable Ignition project. Set-up was fine but when the engine is running the RPM readout is erratic. It is a points system. The debounce is set to maximum. Any ideas? (M. W., via email).

- The points are probably causing a lot of noise at switching due to contact bounce and mechanical jitter that extends beyond the debounce period

catered for by the Programmable Ignition. One way of preventing this is to add a capacitor across the points.

Since the points are operated at a low voltage, you can use a low-voltage capacitor rated above 16V. Possibly a 1µF capacitor will work OK but you may need a larger value. An electrolytic capacitor would be suitable. Alternatively, change the capacitor at pin 6 of IC1, the PIC microcontroller, to a larger value, eg, 100nF.

The extra delay set by the capacitor for ignition firing can be adjusted out with the Programmable Ignition timing adding more advance as RPM increases.

The best results from the Programmable Ignition are obtained with Hall Effect, reluctor or optical triggering. This is because points will always produce timing jitter due to the cam's opening and closing rate, any mechanical play and contact opening and closing inconsistencies.

Hum problem in the Currawong amplifier

I have a hum problem in the Currawong amplifier. However, when I removed the screws from the front panel and pulled the PCB forward about 60mm, the hum almost disappeared.

It seems obvious that it is caused by the main power transformer being located under the left channel. I have twisted the leads from the transformer to the connection strip and wonder if there is anything else I should try. I have also noted that sometimes switching the unit off and on again cures the hum. (R. W., via email).

● If switching the unit on and off sometimes cures the problem then that indicates that is not caused by the power transformer positioning. Therefore, we are fairly sure that the hum is due to a faulty capacitor or bad solder joint.

Unfortunately, it would be necessary to remove the PCB entirely to check all the solder joints and we know this is a pain because it involves un-doing and re-doing so many connections. However, there is no other way to inspect it properly.

The only other possibility is a faulty valve. Try swapping the valves between the left and right channels. If the problem doesn't move, then that rules out a faulty valve. However, the fact that the hum comes and goes points to the capacitors in the circuit.

Accuracy Concerns With Leakage Current Meter

Attribute	Measured/Observed	Expected
Battery voltage (new set)	6.2V	6.2-6.3V
Current draw (idle)	87mA	–
Current draw (test)	120mA	–
Test point TP1	+3.17V	+3.2V
Test point TP2	Unable to test	2MHz
Test point TP3	+2.47V	+2.5V
LCD terminals open, 500V	Ix = 000µA, R = 641MΩ	Ix = 000µA, R = 999MΩ
LCD terminals open, 1000V	Ix = 000µA, R = 293MΩ	Ix = 000µA, R = 999MΩ
LCD terminals shorted, 500V	Ix = 053µA, R = 000MΩ	Ix = 050µA, R = 000MΩ
LCD terminals shorted ,1000V	Ix = 103µA, R = 000MΩ	Ix = 100µA, R = 000MΩ
LCD ~92MΩ load, 1000V	Ix = 009µA, R = 090MΩ	~Ix = 009µA, R = 090MΩ

I was hoping you might be able to shed some light on a potential issue I'm having with a Digital Megohm and Leakage Current Meter (SILICON CHIP, October 2009) kit purchased from Altronics (Cat. K2556). Some of the results I observed during testing differed from what the assembly instructions suggest I should expect.

The table above outlines what I tested compared with what I was expecting according to the instructions. (K. F., via email).

● From your measured figures, your meter does seem to be operating within the tolerance limits, as determined by the 1% resistors used. However, if you'd like greater accuracy, we suggest that you try connecting a low-value resistor in series with the 5.6kΩ and 270Ω resistors connected between pin 2 of IC3 and ground – to increase the reference voltage at TP1.

If you add a 4.7Ω (1% metal film) resistor in series with the above resistors, this should increase the reference voltage at TP1 to much closer to 3.20V and thus bring the current and resistance readings somewhat closer.

Programmable ignition default has changed

I built your Programmable Ignition System (SILICON CHIP, March-May 2007) some time ago and it has been working fine. Just recently I have been experimenting with the latest Multi-Spark CDI system (December 2014 & January 2015) and running it through the Programmable Ignition System using its inbuilt 5Hz output to trigger the CDI. The 5Hz signal should default to OFF every time power is restored.

Unfortunately, mine now defaults to ON. I can turn it off manually but it always returns to ON when power is applied. The reset function does not change the situation. Everything else appears OK. All the other data had remained in memory before I reset it.

Do you have any ideas, short of purchasing a new PIC? (J. B., via email).

● It seems like the oscillator is set to ON. To fix this go into settings by placing LK1 in the settings position. Select "oscillator" and set it to OFF. That is what you have already tried but there is an extra step required. Select "Edge" and change from the setting you have to the alternative setting, then change this back to the original setting. Now the oscillator should be OFF when the engine is started.

Questions on Battery Condition Checker

I am thinking of constructing the Battery Condition Checker from the August 2009 issue of SILICON CHIP. I am wondering what is the smallest SLA battery that can be safely checked?

I am thinking that a current of 12A may be too great for a 4.4Ah or 7Ah SLA battery. If that is the case, is it possible to modify the circuit to include a mechanical switch between earth and three of the 5W resistors to switch out sections of the circuit and therefore reduce the testing cur-

. . . continued on page 111

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. . . continued from page 109

rent to suit smaller batteries?

I have noticed that there are a few battery checkers for sale at the moment. One that crops up a bit in an internet search uses the method below. It is around $70 on eBay. They are typically described as: "This Battery Analyzer is designed to test the condition of the automotive battery using conductance method. Unlike the conventional method of draining the battery by applying resistance load to it and obtain the result from the meter gauge; this analyzer utilizes a series of pulsed voltage across the battery cells and observes the AC current that flows in response to it".

I cannot bring myself to buy it as I cannot convince myself that it will work. I am thinking that as your design is now over six years old, it may be worthwhile designing a updated model? (R. M., via email).

● You may be right in wondering if a test pulse current of 12A may be too great for small SLA batteries, at least for those rated at 4.4Ah and below. Lifting the earthy end of say two of the 0.22Ω 5W resistors via an added switch would certainly drop the pulse current for the three range settings of switch S2 to 8.2A, 13.6A and 19.1A .

The 8.2A figure would probably be OK, even for a 4.4Ah SLA battery. However, this would also mean that only two of the switching Mosfets would have to share the load.

A better way might be to lift the earthy ends of all four 5W resistors and run them to earth via an added switch. Then, in addition, connect two 0.1Ω 5W resistors in parallel across the switch, so that when it's in the open

. . . continued on page 112

Notes & Errata

The Majestic Loudspeaker System (June & September 2014): constructors should be aware that there were a number of errors in the June 2014 issue on building the Majestic Loudspeaker which were corrected in the September 2014 issue. For example, there was confusion over the size of the gap between the angled panel and rear panel; its specified 1.5mm width is correct but this results in a gap area of 6.3cm^2, not 63cm^2 as stated in the original article.

In addition, the acoustic wadding used in the prototype is acrylic, not BAF and some of the dimensions in Fig.5 were wrong or missing. Corrected diagrams were published in the September issue.

Also note that the horn used in the original prototype, as specified in the June 2014 issue, is no longer available so constructors will need to use the better Celestion horn as explained in the September update.

Finally, some readers have been unable to purchase the eTone type 1525 woofer. While this would still be our preferred part, the Celestion 28/FTR15-4080FD woofer is a valid alternative. This will fit in the same cut-out and has greater power handling capability. It costs more than the eTone woofer but may be easier to obtain.

6-Digit Nixie Clock, Mk2 (February & March 2015): an error was found in the routine which applies the time zone offset. This results in the clock displaying hour 24 rather than 00 after midnight. It can also result in an incorrect hour display for the first minute of each hour in time zones with a half-hour or quarter-hour offset.

The latest version of the firmware (1910215D.hex), available on our website, fixes both problems. Users affected by these bugs can mail their PIC32 chip to our PO Box along with a return address for re-programming (be sure to specify that the chip is for the Nixie Clock).

Low-cost, Accurate Voltage/Current/Resistance Reference (August 2015): the caption for the PCB photos on page 43 is wrong. If diode D1 is fitted, its cathode goes to the positive battery terminal, not its anode. The photo shows the correct orientation.

PICAXE-Based Mains Timer, Circuit Notebook (August 2015): the circuit shows D1-D2 as 1N4148s. D1-D5 are all 1N4004 types.

Ask Silicon Chip

. . . continued from page 111

position the total emitter resistance switches from 0.05Ω to 0.105Ω. This will produce pulse current figures of 8.6A, 14A and 20A for the three range positions of S2 and all four Mosfets will still be sharing the current. SC

Next Issue

The October 2015 issue of Silicon Chip is due on sale in newsagents by Thursday 24th September. Expect postal delivery of subscription copies in Australia between September 23rd and October 6th.

Advertising Index

Altronics 74-77
Aust. Exhibitions & Events 40
Control Devices Group 47
Element14 ..... loose insert
Electrolube 43
Embedded Logic Solutions 46
Emona Instruments 45
Front Panel Express 9
Hare & Forbes 2-3
Hammond Manufacturing 44
Harbuch Electronics 13
Icom Australia 12
Jaycar IFC,53-60
KCS Trade Pty Ltd 11
Keith Rippon 111
Keysight Technologies ..... OBC
LD Electronics 111
LEDsales 111
Mastercut Technologies 43
Master Instruments 7
Microbee Technology 71
Microchip Technology 5,89
Mikroelektronika ..... IBC
Ocean Controls 10
Qualieco Circuits Pty Ltd 50
Questronix 111
Rohde & Schwarz 51
Rolec OKW 42,46
Sesame Electronics 111
Silicon Chip Online Shop 101
Silicon Chip Subscriptions 110
Silvertone Electronics 73
Threadboard 69
Tronixlabs 111
Virtins Technology 8

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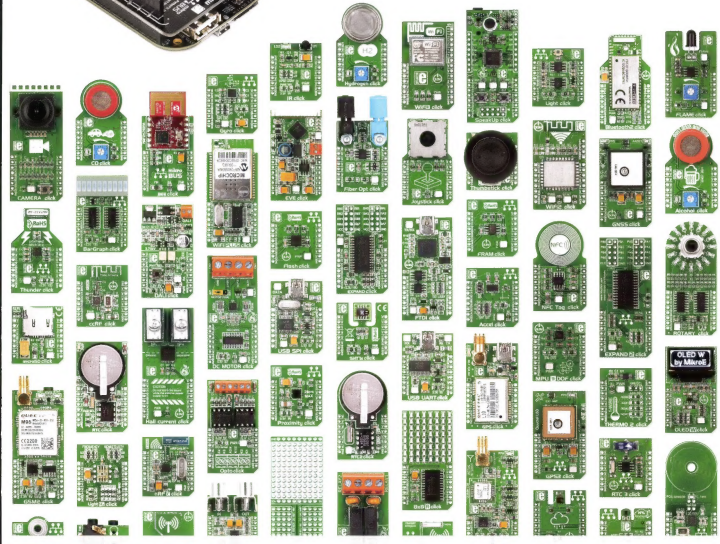

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